FINAL REPORT

FEASIBILITY STUDY OF A STORAGE COOLING SYSTEM FOR DEFENSE MEGACENTER (BLDGS 350 & 390) AT ROCK ISLAND ARSENAL, IL

Prepared for

Department of The Army
Rock Island Arsenal
Directorate of Public Works
ATTN: SMCRI-PWE/ Mr. David Osborn
Rock Island, Illinois 61299-5000

Prepared by

Department of The Army
U.S. Army Corps of Engineers
Construction Engineering Research Laboratories
Utility Systems Division
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Champaign, Illinois 61826-9005

Principal Investigator
Chang W. Sohn, Ph.D., P.E.

24 July 96

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1. INTRODUCTION

1.1 Background

As a part of the Energy Engineering Analysis Program (EEAP), the feasibility of thermal energy storage at Rock Island Arsenal (RIA), IL has been studied in this report. The sponsor of the EEAP program is HQUSACE with Point of Contact (POC) being Mr. Dan Gentile, CEMP-ET. Mr. Tony Battaglia of Mobile District, CESAM-EN-DM, is with the Technical Center of Expertise for the EEAP program. The POC at Louisville District is Mr. Charles Lockman, CEORL-ED-MS, and the POC at Rock Island is Mr. David Osborn, SMCRI-PWE. This report was prepared by USACERL with Dr. Chang Sohn working as Principal Investigator and Mr. Douglas Anderson and Mr. Brian Boughton working as Research Assistants. The building load was simulated with the BLAST program by Dr. Rich Liesen of the BLAST Support Office at the University of Illinois.

Bldg 350 is a 6-story administration and computer center with 446,477 sqft of floor area, which includes a computer area with extremely high internal load. Bldg 390 is a 4-story administrative building with 150,845 sqft of floor area. This study includes a review of current cooling systems, the feasibility of storage cooling systems, and identification of other energy conservation opportunities related to cooling these buildings.

1.2 Problem Statement

Is the current cooling system energy efficient and can it meet the cooling requirements of Bldgs 350 and 390 economically? Would a storage cooling system be a cost effective addition to the current cooling system? What other energy conservation opportunities can be found in cooling the subject buildings?

These questions are answered through a review of previous energy studies, BLAST simulations of the peak day cooling loads using the annual design weather data by hour at Moline, IL, and study of a prototype chilled water storage (CWS) cooling system. Development of a prototype CWS cooling system is based on a site survey. The evaluation of potential savings in electrical demand cost and energy conservation by free cooling is made for computer rooms in Bldg 350. A payback period of the prototype system was calculated from the system first cost estimate and the expected annual savings in the electrical utility costs.

1.3 Scope of Study

This report discusses the energy conservation and cost saving opportunities in the current cooling systems of Bldgs 350 and 390. The feasibility of a CWS cooling system for the buildings is based on a prototype system. The prototype system was selected through a feasibility analysis tool, STOFEAS. BLAST output and site chiller data are used for load estimate and system storage capacity sizing. The payback analysis of the selected prototype system is based on

available data for RIA's electricity consumption, electric utility rates, and the prevailing CWS cooling system cost data. The actual design of a system is beyond the scope of this report.

2. REVIEW OF CURRENT COOLING SYSTEM FOR BLDGS 350 AND 390

2.1 Cooling Load for Buildings 350 and 390

Bldg 350, built in 1918, is a six story structure with 446,477 sqft of floor area. It is a converted warehouse facility now being used as an ADP computer center, administrative offices, communication center, and a post restaurant. Bldg 390, built in 1942, is a four story building with a basement which is half below grade that contains office space.

The following information was used to simulate the cooling load of bldg 350 by BLAST program. The exterior walls are of concrete block which are not insulated. The roof is reinforced concrete with wood deck and built-up roofing. Windows are single pane glass with Venetian blinds. The thermal load from lighting is between 1.5 and 1.7 W/sqft, with minimal lighting in halls and unoccupied areas. The floors from the second to the sixth have a high density of people. The occupancy time for the 2,800 people is between 0600 and 1700 for five days a week. Thus, the density is estimated to be 159 sqft/person. The exterior surface area was estimated to be 230,220 sqft. The ratio of the window area to the floor area is 6.7 percent. The window load is estimated to be 30.4 percent of the total cooling load. The overall U factor of the building is 0.280 Btu/hr deg F sqft.

Bldg 390 is shaped like the letter "H" and the gross floor area is 150,845 sqft. The walls consist of ten inch thick reinforced concrete slabs. The roof consists of three inch concrete, one inch thick insulating board, and built up roofing with gravel. The basement windows are double hung wood frame with single pane glass. The windows throughout the remainder of the building are steel sashed operable windows. The windows in Bldg 390 are accompanied with Venetian blinds. Newer aluminum frame inner storm windows have been added on the above grade floors. Lighting is considered moderate to low for an office building of this type.

A detailed report on the BLAST simulation of building loads for Bldg 350/390 is attached in Appendix A. According to the BLAST output based on Moline, IL weather data, the worst peak day cooling demand for Bldg 350 is 1,333 tons, including 534 tons for the computer rooms in the first and the second floor. The peak load for Bldg 390 is estimated to be 348 tons. Therefore, the total cooling load to be met by the cooling equipment is 1,681 tons. Figure 1 shows the hourly cooling load expected on the worst peak day, and Figure 2 shows the current arrangement of cooling equipment meeting the cooling loads of Bldgs 350 and 390.

Note that a unique cooling requirement exists for the computer rooms in Bldg 350. The rooms are located in the interior of Bldg 350; therefore, they are subject to relatively constant ambient conditions, i.e., are surrounded by the conditioned office spaces. The computer rooms are, however, densely populated by internal heat sources (i.e., computer equipment) and have to be cooled continuously year round.

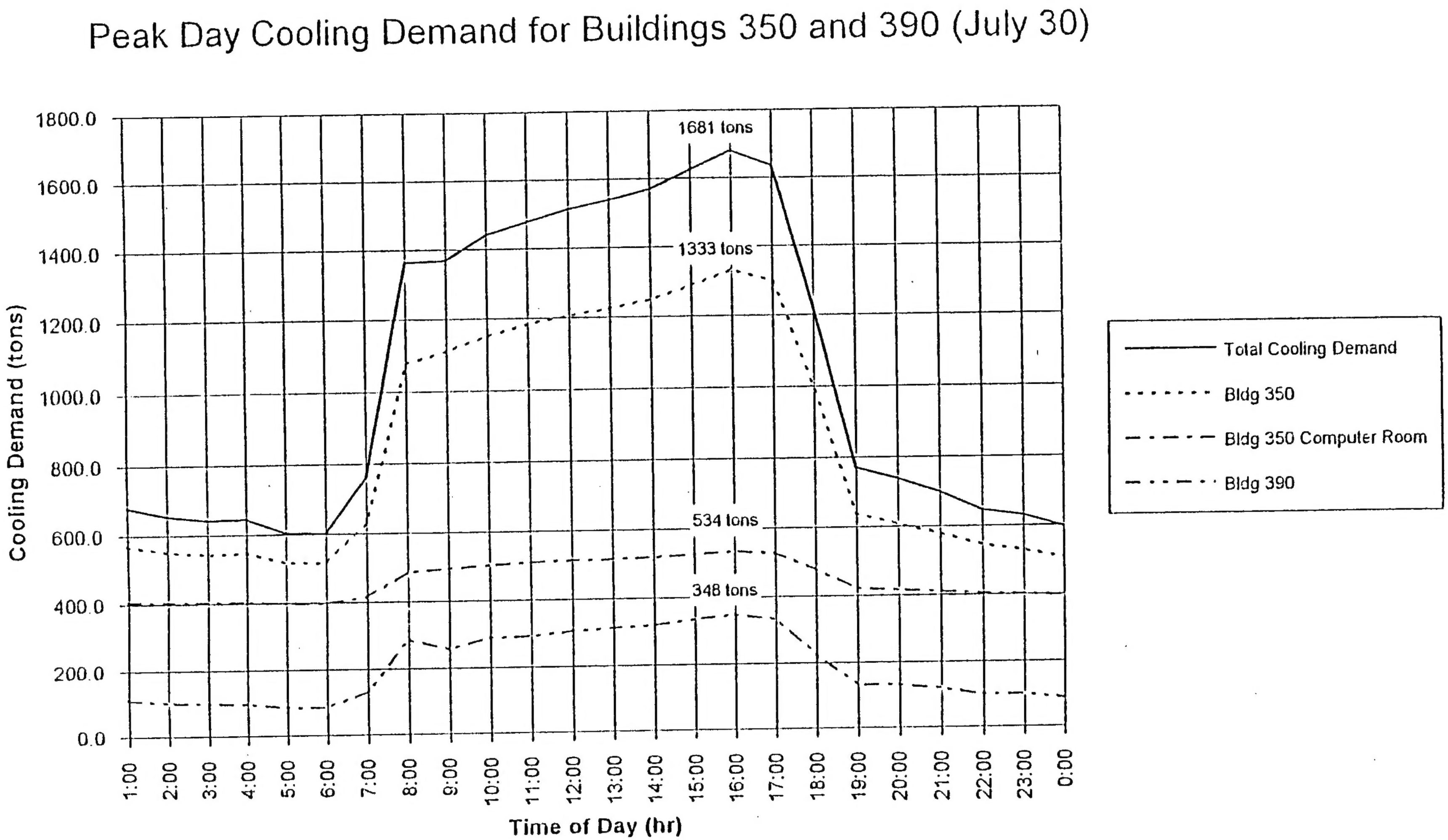


Figure 1. Simulated peak cooling load for Bldgs 350 and 390.

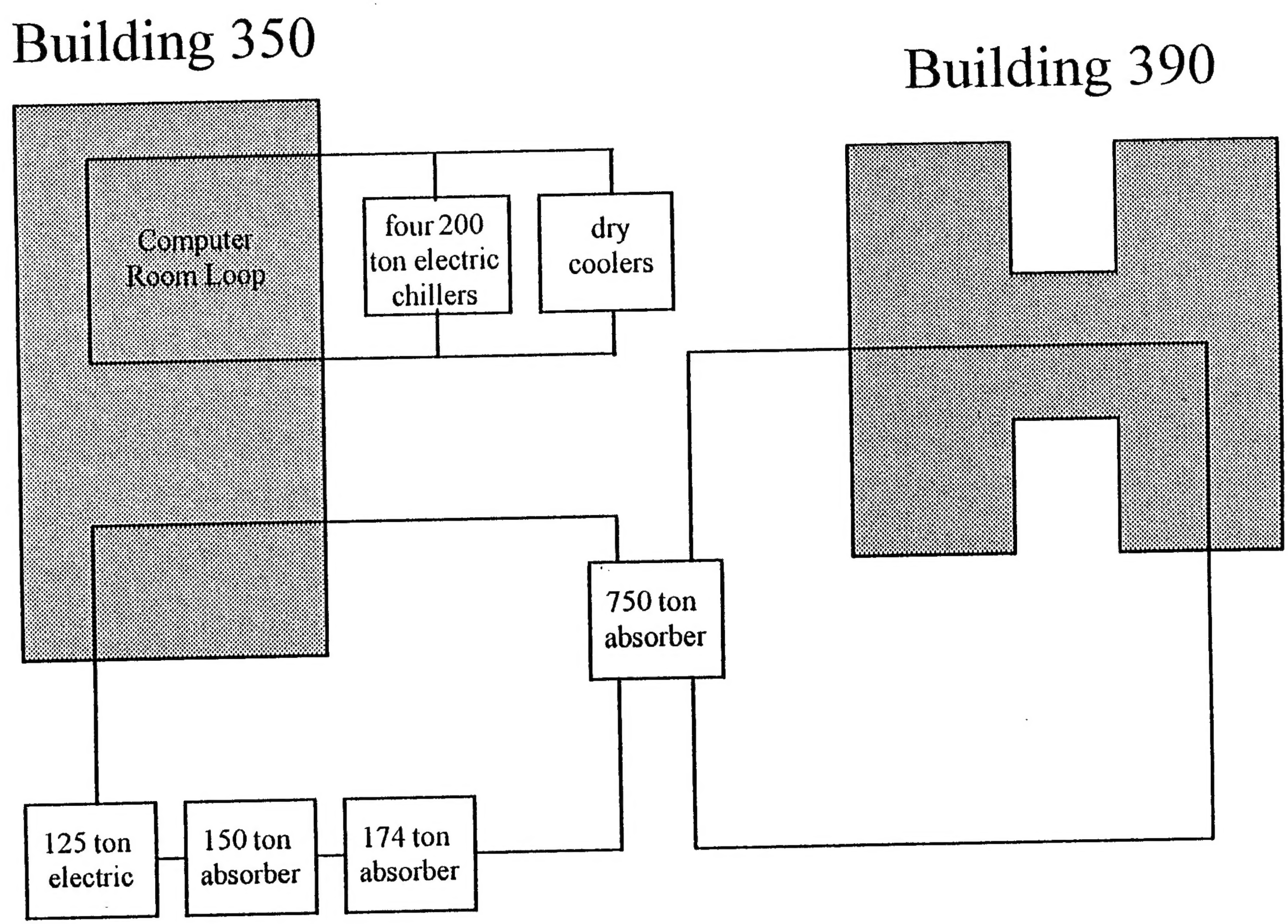


Figure 2. Schematic diagram of current cooling system.

2.2 Current Cooling Systems

Site visits were made to the Rock Island Arsenal on 15 February 1995 and 25 May 1995. Appendix B includes photographs of cooling equipment and the buildings of interest in this study. During on-site examinations of cooling equipment, schematically shown in Figure 2, the following observations were made:

a. Total cooling capacity of existing equipment is 1,999 tons, to meet the estimated worst peak cooling load of 1,681 tons (see Section 2.1 above). In a breakdown, the BLAST estimate of 1,147 tons for office cooling (excluding the 534 ton load from the computer rooms) can be adequately met by the existing equipment with the 750 ton absorption chiller as the base load provider, and a 174 ton absorption chiller, a 150 ton absorption chiller, and a 125 ton electric chiller as peaking units. The cooling capacity of these chillers is 1,199 tons, which should be sufficient to meet the estimated worst peak load of 1,147 tons.

b. The absorption chillers for cooling the office areas are excellent choices for economical cooling of Bldgs 350 and 390. They do not aggravate the electrical demand profile or incur any electrical demand cost in cooling these buildings. They should be able to help the central boiler plant run steadily during the summer when the steam demands are low. Another significant advantage of these chillers is that they do not contain any CFC/HCFC refrigerants that must be phased out or replaced within a few years.

c. Due to the adequate sizing and the economical type of cooling equipment present in Bldgs 350 and 390 (excluding the computer rooms), no alteration of current cooling equipment is to be suggested at this time.

d. The year round cooling of computer rooms in Bldg 350 offers an interesting opportunity for energy conservation. Especially during the winter, the outdoor chill can provide the cooling to the computer rooms. The free cooling opportunity, however, is already being utilized with outdoor free cooling units (dry coolers). A dry cooler is a free cooling device when the ambient temperature is low. The cooling medium (ethylene glycol solution) is chilled by an outdoor air cooled heat exchanger rather than by a chiller evaporator. Pictures of dry coolers, installed for Bldg 350, are shown in Figures A4 and A5 in Appendix B.

e. The computer rooms are cooled by four units of R-22 400 ton electric chillers. The BLAST load estimate is 534 tons for a peak load for the computer rooms. Hourly operational data on the four units were collected between August 7 and August 13 of 1995. Results indicated that the total cooling load remained relatively constant throughout each day at a value of about 500 tons. The peak total cooling load during this period was measured to be 517 tons.

2.3 Energy and Cost Savings Opportunities for the Computer Rooms

The above observations (in Section 2.2) suggest that the cooling system for Bldgs 350 and 390 is well designed (in terms of cost of operation as well as environmental concerns), and adequate to cool the buildings. Further opportunity to improve energy efficiency and cost saving may be found only in cooling the computer rooms in Bldg 350. One concern is that two out of the four chillers dedicated to cool the computer rooms may need replacement in the near future.

One was installed in 1987 and the other in 1989. In normal usage of a chiller, an age of six and eight years may not be old enough to warrant replacement. Note, however, that these chillers are running continuously year round, thereby accumulating three to four times more run-hours compared to a typical chiller operating only during the cooling season. Energy and cost savings potential with a CWS cooling system in conjunction with the replacement of these two chillers will be the main subject of the remainder of this report. Due to the critical mission of the computer facilities, the reliability and redundancy of the system should be a particular concern for cooling the computer rooms.

3. PRELIMINARY FEASIBILITY ANALYSIS

3.1 Rock Island Arsenal Electric Resources

3.1.1 Installation-wide Demand Characteristics

In considering a chilled water storage (CWS) cooling system, the most critical information is the billing demand (i.e., peak day electric demand) profile of the facility the system is to service. Figures 3 and 4 show the peak day demand profile for Rock Island Arsenal (RIA) in Aug 1990 and in July 1980. Figure 3 information came from data collected at Rock Island and Figure 4 information came from the GARD Study of 1983. The profiles show a high plateau from 0800 to 1400 with a peak of 20,800 kW at 1100. It provides sizing for a window of shift from on-peak to off-peak. The historical data indicates that this window has remained at the same time period over the years, which is important for the design of a chilled water system. A 5-hr window (0900-1400) would cover the first four percent of the total demand, i.e., a shift of 800 kW from the on-peak period to an off-peak period would reduce total electric demand by about four percent.

3.1.2 Electric Rate Structure

The Iowa-Illinois Gas and Electric Company provides electricity to Rock Island Arsenal based on Rate No. 53 - Large Industrial Electric Service [Reference 1, attached in APPENDIX C]. It has no ratchet clause for determination of the monthly demand charge. The demand charge is $10.55/kW for summer months (Jun-Sep) and $5.75/kW for all other months. The cost of electricity also varies for on-peak or off-peak periods. The on-peak rate is $0.0347/kWh and the off-peak rate is $0.0214 /kWh. On-peak hours are defined by the electric utility as daytime periods between 0800 and 2000 Monday through Friday during the month excluding the United States legal holidays which are listed in the rate structure in APPENDIX B. A breakdown of monthly electric utility costs for fiscal year 1994 is shown in Table 1.

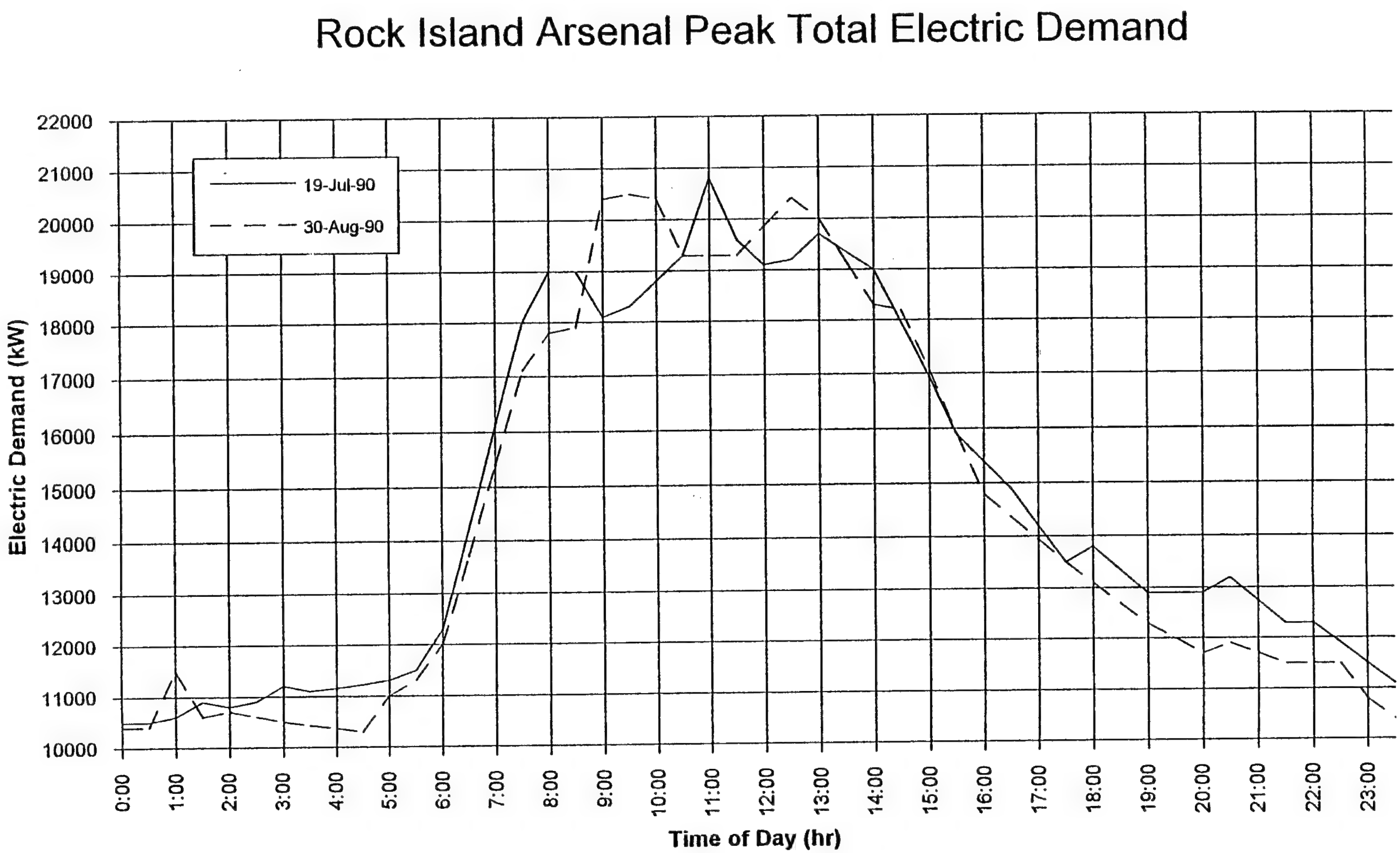


Figure 3. Hourly electrical demand for the peak day in 1990.

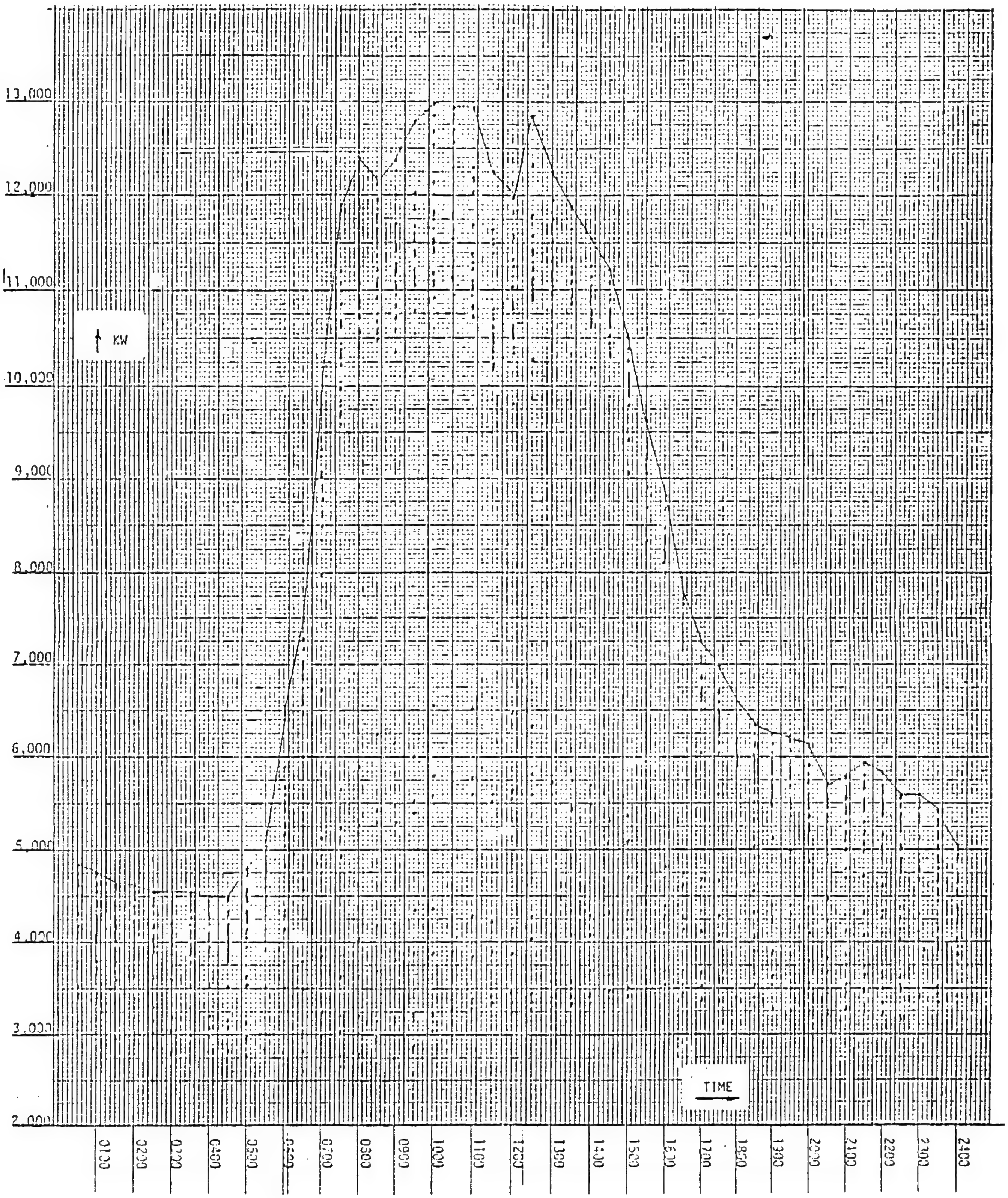


Figure 4. Hourly electrical demand profile for the peak day in 1980.

Table 1. Monthly Electric Utility Bill for FY94

Month	Total Bill	Demand Cost	Energy Cost
Oct	$331970.17	$101211.50	$230758.67
Nov	$301659.23	$97157.75	$204501.48
Dec	$319097.37	$98969.00	$220128.37
Jan	$324150.86	$98606.75	$225544.11
Feb	$330234.87	$103965.75	$226269.12
Mar	$370561.60	$104029.00	$266532.60
Apr	$325484.70	$110561.00	$214923.70
May	$355772.78	$108893.50	$246879.28
Jun	$476609.79	$215346.60	$261263.19
Jul	$502674.98	$221729.35	$280945.63
Aug	$481486.72	$208837.25	$272649.47
Sep	$456856.80	$202053.60	$254803.20
TOTAL	$4,576,559.87	$1,671,361.05	$2,905,198.82

Note that the bills for FY 1994 are based on the annual peak electrical demand of 21,017 kW, which is slightly higher than the 20,800 kW shown in Figure 3 for 30 Aug 1990. Due to the negligible changes in the variation of peak electrical demands, analysis of a shift window based on the 1990 data will be as good as the one with the current year demand data.

3.1.3 Specific Annual Demand Cost Savings for Shift of 1 kW

The electrical demand cost savings in shifting 1 kW from on-peak to off-peak period is,

(1) $S = 4*10.55 + 5.75*8$
$= \$88.20/kW/yr$

where S is the specific annual demand cost savings. Four summer months in a year are subjected to a demand charge of $10.55/kW per month, and eight non-summer months are under $5.75/kW per month.

3.2 STOFEAS Analysis

Based on RIA's peak day demand profile (Figure 1) and the IIGE's electric rate structure (Section 3.1.2), a feasibility analysis of cool storage was performed with STOFEAS. STOFEAS is a simple, interactive PC program for economic feasibility analysis of storage cooling systems, based on the algorithm developed in a USACERL Technical Report [Reference 2]. The program calculates payback periods and saving-to-investment ratios based on user-provided data pertaining

to electricity consumption, rate structure, and the built-in specific system construction cost model.

Results of the STOFEAS analysis under the IIGE rate structure are provided in APPENDIX D. They are based on a default cost model that quotes $80/ton-hr for a new/replacement application, $150/ton-hr for a retrofit application, and $300/ton-hr for an upper-limit test application. The output serves as a rough guide to the feasibility and optimal size of a cool storage. A detailed feasibility study follows in the following sections for the case of replacement of two electric chillers for the computer room cooling.

3.3 Prototype Storage Cooling System for Computer Rooms

Results from the STOFEAS analysis described in section 3.2 show that the most cost-effective size of cool storage would be one that would shift 1-3% of the total electrical demand of RIA. It is reasonable that the first few percent of the load would require the minimal storage capacity (and cost) due to a smaller demand-shift window.

The peak cooling load for the computer rooms is estimated to be 534 tons (see Section 2.1). At an assumed rate of 1.2 kW/ton of existing air-cooled chiller performance, the maximum demand that could be shifted from an on-peak to an off-peak period is 641 kW. This amounts to about 3 percent of the peak demand of RIA. For a typical storage cooling system of this size, the STOFEAS prediction shows a 6 year payback period. However, due to the unique round-the-clock cooling requirement of the computer rooms, a customized analysis is required as in the following sections.

4. PROTOTYPE CHILLED WATER STORAGE COOLING SYSTEM FOR COMPUTER ROOMS

4.1 System Sizing

A prototype storage cooling system for this study would shift the peak cooling load (534 tons) of the computer rooms in Bldg 350 from a selected window to an off-peak period. A typical air-cooled reciprocating chiller would run at an energy consumption factor of 1.2 kW/ton of cooling. Therefore, turning off the chillers for the computer rooms in Bldg 350 will reduce the peak electrical demand by 641 kW. An examination of the installation-wide demand profile in Figure 3 shows that a system with a 5-hour window (0900-1400) will meet the requirement. However, taking into account minor variations in the demand profile in the future, a 6-hour period (0800-1400) will be selected as the window of operation for the selected prototype storage cooling system.

To shift a cooling load of 534 tons of cooling for a 6-hour window, the required storage capacity of the system is

$$
\begin{aligned}
(2) \qquad C &= Q * W \\
&= 534 \text{ tons} * 6 \text{ hours} \\
&= 3{,}204 \text{ ton-hours}
\end{aligned}
$$

where C is the storage capacity in ton-hours, Q the cooling rate in tons and W the size of window in hours. Since the required storage capacity is greater than 2,000 ton-hours, a chilled water storage (CWS) cooling system is preferred to an ice storage cooling system [Reference 3].

A schematic diagram of the prototype CWS cooling system is shown in Figure 5. For a typical CWS cooling system, an intermediate heat exchanger between the load loop and the tank loop is not required. Note, however, that an intermediate heat exchanger is required in our application because the load loop is charged with brine (ethylene glycol solution) and the tank loop will be filled with water. Due to the cost and environmental concern of the ethylene glycol as well as the thermal characteristics of the glycol solution (lower specific heat and higher viscosity), brine is not recommended in the tank loop.

For a CWS system, a typical design temperature difference between the supply and return water is 15-20 F [Reference 4]. For a conservative calculation of the storage volume, a 10 F delta T will be assumed in this analysis, since it is the typical delta T observed at central cooling plants in Army installations. The tank storage efficiency reported in the literature from field performance monitoring ranges from 70 to 90 percent [Reference 4]. The required volume of water is given by

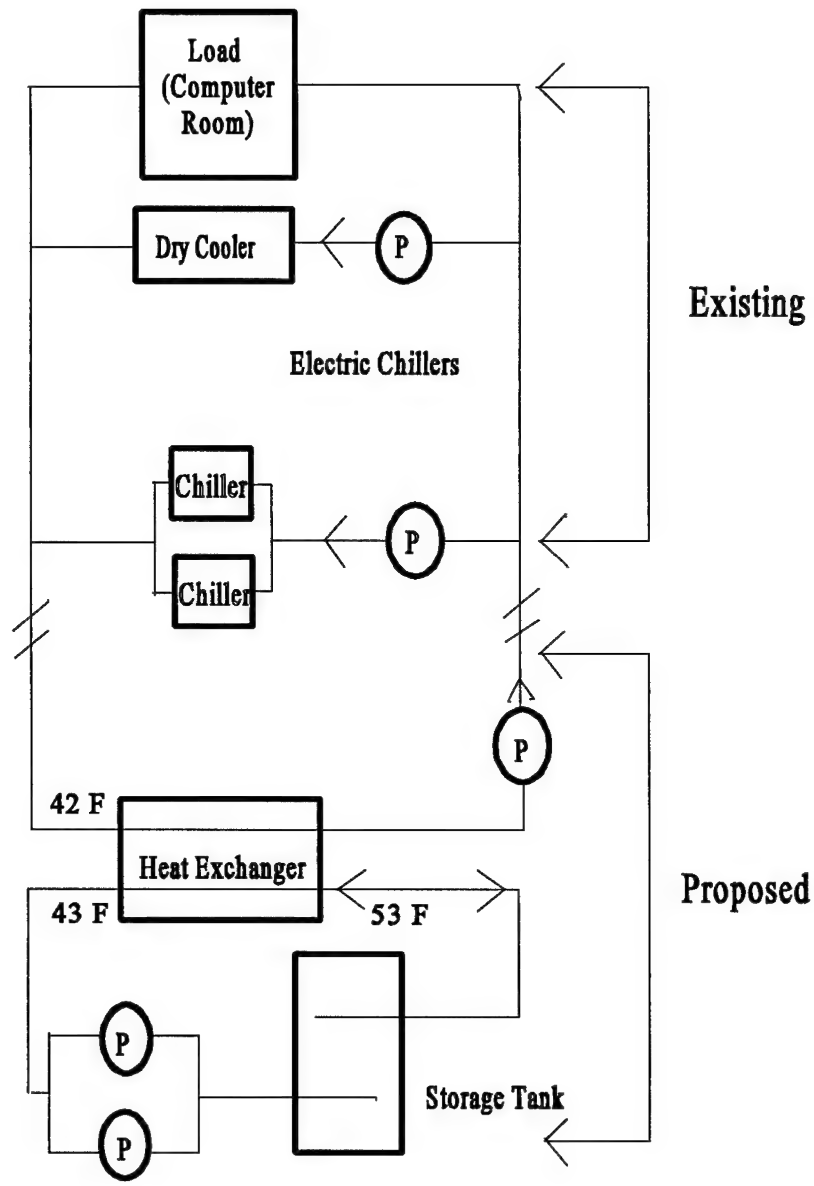


Figure 5. Schematic diagram of prototype CWS cooling system.

(3) V = (C * 12,000 BTU/t-h)/(8.33 lb/gal * h * delta T * e)
= (3,204*12,000)/(8.33*1*10*0.75)
= 615,414 gallons

where h is the specific heat of water (1 BTU/lb* F), delta T is the temperature differential, and e is the tank storage efficiency including an intermediate heat exchanger. Note that a conservative choice, delta T = 10 F and e = 75%, was used for calculation of required tank volume.

4.2 Prototype System Tank Construction Cost

4.2.1 Direct Quote

For a similarly sized CWS system, a manufacturer's budgetary quote for a turnkey base installation cost is roughly $0.55/gal ($3.54/cu ft). It is an above-ground, circular, insulated steel tank with approximately 1,000,000 gallons of water storage capacity. Based on a cost of $0.55/gal, the total prototype system construction cost is

(4) TC = $0.55/gal * V
= $0.55/gal * 615,414 gallons
= $338,478

where TC is the total system-installed cost and V is the total storage volume required. In this estimate, the cost of an intermediate heat exchanger is not included.

4.2.2 Cost Data from Industry-wide Software Program

Table 2 shows the cost parameters associated with CWS cooling systems employed by COOLAID [Reference 5]. COOLAID is a commercially available computer program that analyzes the cost impacts of storage cooling systems for commercial building.

Table 2. Chilled Water Storage Parameters

Size Range (ton-hours)	Volume Required (cu ft/t-h)	Tank Cost ($/cu ft)	Space Cost ($/cu ft)	Interface Cost ($/ton)	Tank Standby Efficiency (output/input)
500-2,000	15-20	6-9	0-4	50-150	0.80-0.98
2,000-10,000	13-20	5-7	0-4	50-150	0.90-0.98
Over 10,000	12-20	4-6	0-4	50-150	0.90-0.98

The volume required, in cu ft/ton-hour, for the prototype system with a storage capacity of 3,204 ton-hours is

(5) $\quad Vf = 3{,}204 \text{ ton-hours} * 20 \text{ cu ft/ton-hour}$
$\qquad = 64{,}080 \text{ cu ft}$

where, Vf is the volume required in cubic feet. The dimensions of a typical chilled water tank of this size would be 30 ft high and 52 ft in diameter. Based on Table 2, using the high number for a mid-size tank, the tank cost (C1) is

(6) $\quad C1 = Vf * \$6/\text{cu ft}$
$\qquad = 64{,}080 \text{ cu ft} * \$6/\text{cu ft}$
$\qquad = \$384{,}480.$

There is no space cost in our application. Note that the space cost in Table 2 applies to commercial buildings with rental space. The interface cost, C2, is given by

(7) $\quad C2 = \$50/\text{ton} * 534 \text{ tons}$
$\qquad = \$26{,}700.$

The total cost estimate for the prototype system, based on Table 2, is the sum of C1 and C2:

(8) $\quad TC = C1 + C2$
$\qquad = \$384{,}480 + \$26{,}700$
$\qquad = \$411{,}180.$

4.2.3 ASHRAE National Survey

In 1994, the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) conducted a national survey of storage cooling systems in operation [Reference 6]. Cost equations for storage cooling systems were developed based on actual cost paid for the construction of the systems currently in operation. According to the cost equation for a retrofit CWS system under 1 million gallons of storage capacity, the cost of the prototype system is projected to be

(9) $\quad TC = 106 * TH - 6{,}895$
$\qquad = 106*3{,}204 - 6{,}895$
$\qquad = \$332{,}729.$

4.2.4 Selected System Construction Cost

The three independent cost estimates (Eqs. (4), (8) and (9)) range between $332,729 and

$411,180. A wide variation of the system installed cost is rather typical in the current CWS cooling industry. According to the ASHRAE Design Guide for Cool Thermal Storage, the storage installed cost for a CWS cooling system is estimated to be $30 to $100 per ton-hr [Reference 4]. The direct quote of $338,478 (Eq. (4)) is selected in this study. The value matches closely with the high estimate in the ASHRAE guide, which would be typical for military construction projects. Also, note that the prototype system was designed conservatively (See Section 3.1). The determination of the system first cost is by no means an exact science. A potential site for the location of the storage tank is shown in Figure 6. Estimates for the cost of equipment and installation are based on the location shown in Figure 6.

Recall that the estimate (Eq. (4)) is based on a typical application of a CWS cooling system with no intermediate heat exchanger between the load and the tank loops. Due to the unique requirement in our application (see Section 4.1), an intermediate heat exchanger is mandatory and its cost must be added to the estimate in Eq. (4). A plate heat exchanger is selected for its low approach temperature and pressure drop. Specifications of the heat exchanger are shown in Figure 7.

The major components for the cost estimate of the heat exchanger loop are: one plate heat exchanger with specifications as shown in Figure 7, one circulation pump rated for 1,280 gpm with 60 ft of head, one circulation pump for 430 gpm with 60 ft of head, material and labor for 100 ft of nominal 8 inch diameter schedule 40 steel pipe, and a control system. Manufacturer cost estimates for the plate heat exchanger and the two circulation pumps are given in APPENDIX E. The pipe schedule selection is based on a water speed of 8 ft/sec during the discharge period. Based on the manufacturers' quotes and the MEANS cost guide [Reference 7], the cost of the heat exchanger is $27,500 for a two degree F temperature approach and $77,000 for a one degree temperature approach, $2,355 for a pump rated for 1,280 GPM with 60 ft head and $1,585 for a pump rated for 430 GPM with 60 ft head, $13,200 for 200 ft of 8-in schedule 40 steel piping, and $6,000 for control. Therefore the extra cost due to the heat exchanger loop is estimated to be $100,140 for one degree approach temperature and $50,640 for two degree approach temperature. A heat exchanger with one degree approach temperature is recommended for this application, and the cost estimate for the heat exchanger loop is selected to be $100,140 (see Section 5.1 for further discussion).

Adding the cost for the heat exchanger loop to the cost of tank construction (Eq. (4)) and also adding 10 percent of the total cost for contingency, 6 percent for design, and 6 percent for project supervision, an estimate of the total system construction cost is given by

(10) $$SC = \$(338{,}478 + 100{,}140) * 1.1*1.12 = \$540{,}377.$$

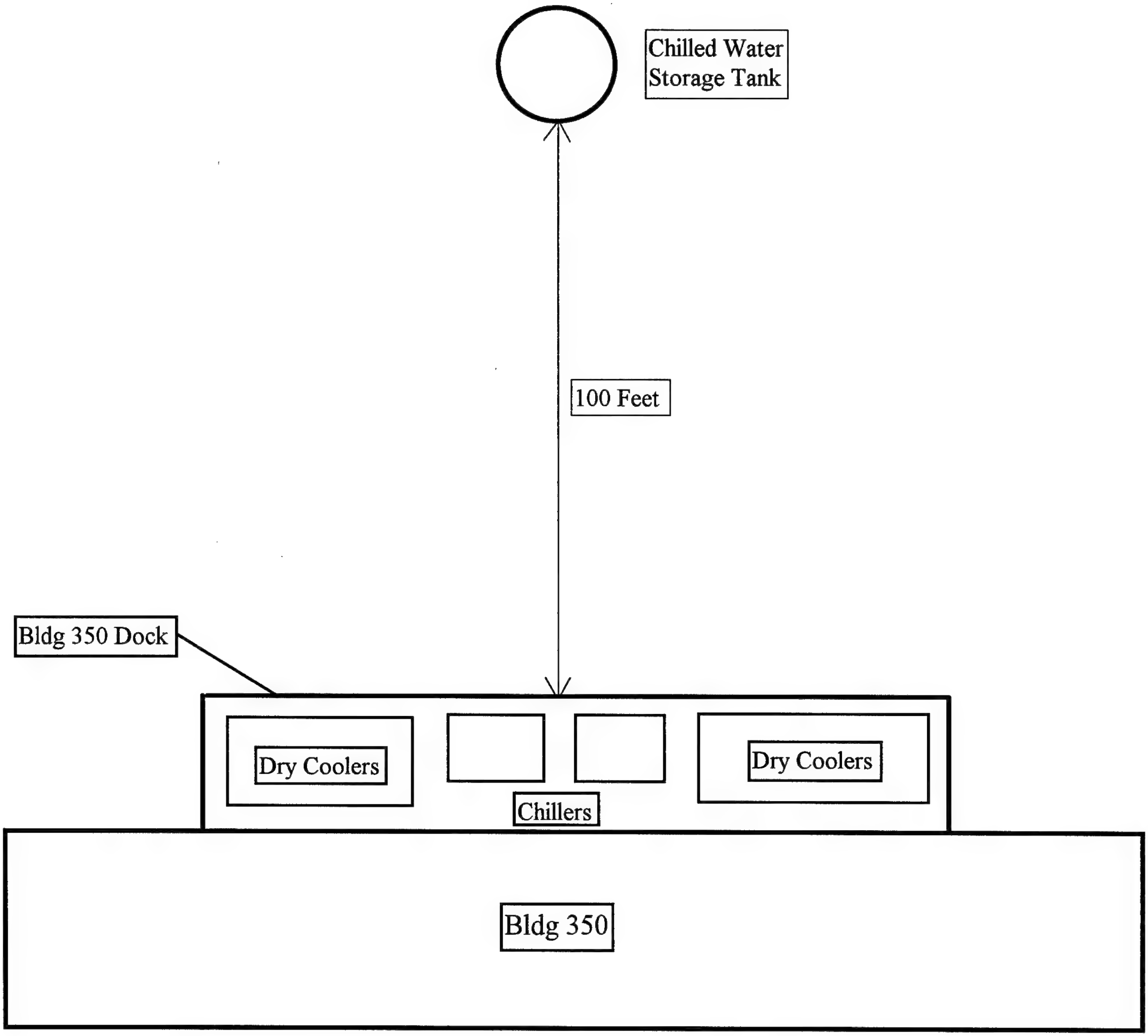


Figure 6. Potential site of chilled water storage tank.

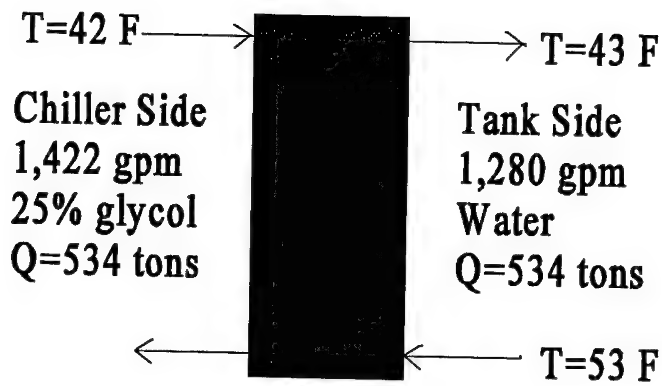


Figure 7. Specifications of intermdediate heat exchanger.

4.3 Annual Cost Savings through Prototype CWS Cooling System

The amount of power shifted from on-peak to off-peak periods by the system is

(11) P = 641 kW. (see Section 4.1)

According to the IIGE rate schedule (attached in APPENDIX C) for RIA and previous monthly billing records (in Table 1), the annual demand savings, S, realized through a reduction of 641, is given by

(12) S = 88.2 * 641 (see Section 3.1.3)
= $56,536/yr

where the specific annual saving per each kW shifted from on-peak to off-peak period is $88.2/kW/yr, as calculated in Section 3.1.3.

The prototype CWS cooling system can reduce energy consumption for cooling by storing outdoor chill when the ambient temperature is low. This energy conservation potential, however, is already fully incorporated in the current cooling system with dry coolers (see Figure 2). The free cooling cost savings are estimated to be $45,846 per year based on the weather data of Moline, IL, as shown on Table 3 on the next page. Due to the existing dry coolers, no extra energy cost savings can be claimed by the prototype CWS cooling system.

The secondary energy cost savings of a CWS cooling system, however, may be added to its annual cost saving benefits. Operating chillers under favorable condensing conditions (i.e., during nighttime) will result in an improved kW/ton ratio of chillers. The improvement in energy efficiency (in KW/ton) in operating the chillers during the non-peaking hours (i.e., during 1400-0900 hours) is assumed to be about 10 percent. Therefore, the total kWh saved in a year will be

(13) SH = 6 (hr/day) * 641 (kW) * 365 (day/yr) * 0.1
= 140,379 kWh/yr

At a cost of $0.0347/kWh during on-peak, the kWh savings in (Eq. 13) will amount to be $4,871/yr.

Another source of cost savings will be the usage of stored off-peak electrical energy in the form of chilled water for cooling the computer rooms during the design window of 0900-1400. Since the cost of electricity during an off-peak period ($0.0214/KWH) is lower than that during an on-peak period ($0.0347/KWH), the savings (SU) in the time of usage will be

(14) SU = 6 (hr/day) * 641 (kW) * 365 (day/yr) * (0.0347-0.0214) ($/kWh)
= $18,670/yr.

Free Cooling Savings - Rock Island Arsenal

Shifted load=	400	tons
Chiller effieciency for that load=	1.2	kW/ton
Power saved=	*480*	*kW*
On-peak TOU rate=	0.0347	$/kWh
Off-peak TOU rate=	0.0214	$/kWh
On-peak period=	12	hrs

	hours of free cooling	free cooling (kWh)	weight factor	on-peak TOU (kWh)	off-peak TOU (kWh)	on-peak savings ($)	off-peak savings ($)
Jan	705	338400	0.483	163405	174995	5670	3745
Feb	637	305760	0.436	133404	172356	4629	3688
Mar	632	303360	0.433	131317	172043	4557	3682
Apr	218	104640	0.149	15624	89016	542	1905
May	40	19200	0.027	526	18674	18	400
Jun	0	0	0.000	0	0	0	0
Jul	0	0	0.000	0	0	0	0
Aug	0	0	0.000	0	0	0	0
Sep	0	0	0.000	0	0	0	0
Oct	203	97440	0.139	13548	83892	470	1795
Nov	457	219360	0.313	68663	150697	2383	3225
Dec	688	330240	0.471	155620	174620	5400	3737
Yr Total	3580	1718400				$23,669	$22,177

TOTAL SAVINGS= $45,846

Table 3. Energy and cost savings through free cooling by dry coolers.

Therefore the total annual savings in electrical utility cost with the prototype CWS cooling systems is

(15) $\quad SVNG = \$56,536 + \$4,871 + \$18,670$
$\qquad\qquad = \$80,077.$

4.4 Simple Payback Period

The payback period of the prototype CWS cooling system can be calculated from the system construction cost, Equation (10), and the expected annual savings, Equation (15). The simple payback period, Y, is

(16) $\quad Y = \$540,377/\$80,077/\text{year}$
$\qquad\quad = 6.7$ yrs.

5. DISCUSSION AND RECOMMENDATION

5.1 Discussion of Results

The current cooling system for Bldgs 350 and 390 offers economical and environmentally sound cooling for the buildings. The absorption chillers for the office space cooling do not incur electrical demand costs for cooling, and the refrigerant is free from chlorofluorocarbon (CFC) concerns. Four electric chillers, charged with R-22 HCFC refrigerants, serve the computer rooms in Bldg 350. They are also free from CFC concerns during their expected service life spans. The current dry coolers are an excellent means to utilize outdoor chill (free cooling) during the wintertime for cooling of the computer rooms. In summary, the current cooling system has been well designed and provides economical cooling service to the buildings.

Further savings may be achieved by reducing the billing electrical demand of the electric chillers serving the computer rooms. A chilled water storage cooling system is an excellent candidate to eliminate the billing electrical demands of the electric chillers. The secondary benefits of the system are utilization of off-peak electricity at a lower cost ($0.0347/kWh on-peak versus $0.0214/kWh off-peak) and improved energy efficiency (kW/ton ratio) of the air-cooled electric chillers. The monetary values of these savings were estimated to be $56,536/yr in demand cost reduction, $18,670/yr in lower kWh charge, and $4,871/yr in improved energy efficiency. At an estimated system construction cost of $540,377, the total annual savings of $80,077 yield a simple system payback period of 6.7 years, which is highly favorable for the project.

If a heat exchanger with a two degree approach temperature is allowed, the payback period will be shortened to 5.3 years. Assuming the temperature of the chiller output brine is 42 deg F, the CWS cooling system will deliver 44 deg F chilled water to the load with an intermediate heat exchanger of one degree approach temperature. With a heat exchanger with two degree approach temperature, the system will provide chilled water at 46 deg F. The temperature (46 deg F) may be too high for the air handler for the computer rooms. This is why a heat exchanger with one degree approach temperature was selected for the prototype system.

The two 200-ton electric chillers on the cooling deck may have to be replaced in the near future. Since the computer rooms need round-the-clock cooling on a daily basis, the CWS cooling system CANNOT be used for capacity augmentation. When the existing chillers end their service, two new chillers with the same capacities must replace the existing chillers. Recall that when a CWS cooling system is installed, the charging of the tank will be accomplished by the capacity of the four chillers which remains after satisfying the computer room cooling load. Therefore, installation of a CWS cooling system is independent of the replacement of the two old chillers. An intangible benefit of a CWS cooling system will be an additional backup capability when two or more chillers fail simultaneously. The 3,204 ton-hr of cooling capacity in the tank should be able to provide emergency cooling while the chillers are being repaired. The monetary value of redundant backup capability of the CWS cooling system was not considered in the payback period calculation

5.2 Recommendation

Adding a 3,200 ton-hr chilled water storage cooling system to cool the computer rooms in Bldg 350 is recommended as an energy cost saving measure. The payback period of 6.7 years for a CWS cooling system for the computer rooms in Bldg 350 merits the system a worthwhile project to reduce the cooling costs for the computer rooms. No further changes are recommended for the remainder of the existing cooling system of Bldgs 350 and 390.

REFERENCES

1. GARD Study final report, November 1983

2. Rate No. 53 Large Industrial Electric Service, Iowa-Illinois Gas and Electric Company, Effective January 15, 1994.

3. "STOFEAS: A Personal Computer Program for Estimating the Economic Feasibility of Storage Cooling Systems," USACERL Technical Report FE-93/12, C.W. Sohn and J.H. Kim, Dec 1992.

4. "Lessons from Field Demonstration and Testing of Storage Cooling Systems," EHSC Technical Note, TN 5-670-1, Apr 1992.

5. Design Guide for Cool Thermal Storage, ASHRAE, 1993.

6. Regional Economic Research, Inc., User's Guide for COOLAID 2.1: A Technology Assessment Tool for Cool Storage Systems, 1990.

7. Study of Operational Experience with Thermal Storage Systems - Results of a National Survey of Cool Thermal Energy Storage Systems, ASHRAE Research Project 766, May 1994.

8. MEANS Mechanical Cost Data, 18th Annual Edition, 1995.

Appendix A

BLAST Simulation Report for Bldg. 350 & 390 at Rock Island Arsenal

BLAST Support Office / University of Illinois
Richard J. Liesen Ph.D.

June 20, 1996

Building 350 Model

Overview

The Building 350 at Rock Island Arsenal is a six story building that houses extensive computer facilities for the United States military. The presence of these computer rooms made it necessary to use a program like BLAST to model the building loads. On the first and second floor, there are four zones (2,4,7, and 9) which have no exposure to the outside environment. In addition to the typical internal loads present in an office environment, two of these zones (4 and 9) contain an extremely high number of computers. These four interior zones (2,4,7, and 9) were to be served by fan system #1. On both the first and second floor, the remaining area was divided into six exterior zones (1,3, and 5). These zones were to be served by fan system #2. Each of the remaining four floors (3 - 6) were broken up into three zones of the approximately same size. Each of these twelve zones (6, 8, 10 through 22) have an exterior perimeter area as well as an interior office space. This last group of zones was to be served by fan system #3. Below in Figure 1 is a schematic which shows the geometric layout of the zones as well the fan system that serves each zone.

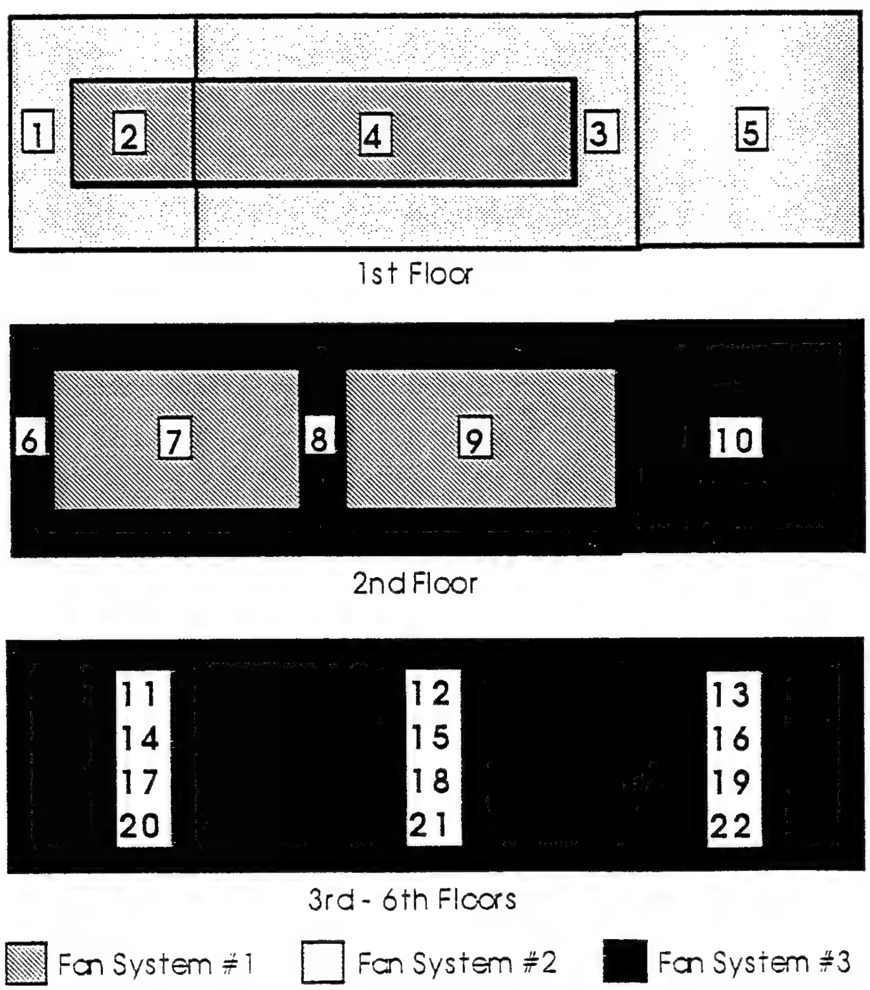


Figure 1

The zones were grouped together in this way because of load characteristics of the zones (interior vs. exterior) and the physical location of the zones within the building. Table 1 shows the internal loads that were scheduled within the BLAST simulation program for each zone.

The assumed internal loads for design conditions for Building 350 are:

People at 1 person per 150 Ft^2,

Lighting at 1.5 W/ft^2 for a moderately lit office building,

Exterior zones were assumed to have 1 air change per hour thru leaky windows.

Equipment Loads are as specified in W/ft^2. The computer room loads (zones 4 & 9) were given to us by management of the Defense Mega Center. The other office areas were assumed at a fairly large amount of computer equipment, copiers, coffee pots, printers, etc., at 3 W/ft^2. Zone 7 was assumed at 5 W/ft^2 since this contained the actual Ready Room for the DMC and was filled with video monitors and associated equipment.

	Lighting [W/ft^2]	People [ft^2/person]	Elec. Equip. [W/ft^2]	Infiltration [ACH]
Zone 2	1.5	150	3	0
Zone 4	1.5	150	31	0
Zone 7	1.5	150	5	0
Zone 9	1.5	150	41	0
Other zones	1.5	150	3	1

Table 1: Internal Loads

As the table shows, the four interior zones were assumed to have no infiltration. This is a good assumption since most of them are high-security, limited-access areas. It should be noted that the infiltration load of the rest of the zones of one air-change-per-hour was based the entire floor area of each zone. This was adjusted later because of the results of the influence coefficients that were calculated for several of the building parameters. This will become more clear as the influence coefficients are discussed in the next section.

Influence Coefficients

One of the benefits of a building load simulation program like BLAST is that the loads for each zone can be quickly calculated again and again once the building model is set up in the proper form. This allows the designer to easily examine the effects of various changes in the building model on the zone loads. This is particularly

useful when examining the effect on zone loads of various load parameters that must estimated by the designer. For example, the internal loads shown in Table 1 had to be estimated by the head designer on this project.

This variation of a result with respect to an input parameter is known as an influence coefficient. Basically, it is equivalent to a partial derivative of the result (load) with respect to one of the input parameters. In our situation, the partial derivative is determined numerically through the use of BLAST. Once the influence coefficient (I.C.) is known, the error in the result due to a particular input parameter can be approximated by multiplying the I.C. by the uncertainty in the parameter. The I.C. and the resulting errors in total loads for the Rock Island Arsenal building were calculated for several input parameters: infiltration, lighting load, people load, electric equipment load, and window shade properties. These results are shown below in Table 2.

Parameter	Design Day I.C.	Range	Design Day Error	Annual I.C.	Annual Error
Infiltration	0.615 $[ACH]^{-1}$	0.50- 2.0 [ACH]	-30.80 % +61.50 %	0.5112 $[ACH]^{-1}$	-25.50 % +51.12 %
Lighting	0.05766 $[W/ft^2]^{-1}$	1 - 4 $[W/ft^2]$	-2.88 % +14.4 %	0.02514 $[W/ft^2]^{-1}$	-1.26 % +6.29 %
People	-3.23E-05 $[ft^2/man]^{-1}$	100 - 300 $[ft^2/man]$	-0.161 % +0.483 %	-7.92E-05 $[ft^2/man]^{-1}$	-0.396 % +1.187 %
Electric Equipment	0.00413706 $[W/ft^2]^{-1}$	1 - 4 $[W/ft^2]$	-0.733 % +0.376 %	0.0097967 $[W/ft^2]^{-1}$	-1.740 % +0.891 %
Shading: Reflectiv-ity	N.A.	0.1 - 0.3 [ ]	N.A.	(-) 0.0033 (+) 0.0245	+0.049 % -0.123 %
Shading: Transmis-sivity	N.A.	0.5 - 0.7 [ ]	N.A.	(-) 0.0457 (+) 0.0147	-0.687 % -0.074 %

Table 2: Influence Coefficients

The results of the table clearly indicate the advantage of calculating influence coefficients for a building simulation. By far, the parameter with the greatest error associated with it is the infiltration. In both the design day results and the annual run results there is significant error associated with the uncertainty of the infiltration. This result tells the designer that he/she should spend more time estimating the infiltration value than the other parameters. It would also be beneficial for the designer to get a better handle on the lighting load estimation. The results of the shading reflectivity and transmissivity are in a slightly different form than the other parameters because two influence coefficients were calculated for each shading parameter. In general, a table of influence

coefficients like the one above tells the designer where to concentrate his/her effort in the process of accurate parameter estimation.

Based upon the extremely high values for the infiltration related error, the infiltration values for this building were re-evaluated. As mentioned before, the CFM value of infiltration associated with 1 ACH was based upon the entire volume of each zone. For some zones (like 1,3,6, and 8), this was a good assumption because they were primarily perimeter zones. However, for the rest of the zones with non zero infiltration (5, 10, and 11 through 22), this was probably not a good assumption. The original infiltration numbers for these zones were probably higher than reality because the zones contain both a perimeter area and interior area of office space. It is doubtful that there would be 1 ACH for the interior areas of the zones. Therefore, it was decided that the 1 ACH value for infiltration should be applied to only to the perimeter area of each zone. This did not change the zoning of the building, only the infiltration values for each zone. After this change was made, new I.C. were calculated separately for the winter and summer design days and are displayed in Table 3.

Parameter	Design Day I.C.	Range	Design Day Error
Infiltration: Summer	0.00342 $[ACH]^{-1}$	0.50- 2.0 [ACH]	-0.17 % +0.34 %
Infiltration: Winter	0.5941 $[ACH]^{-1}$	0.50- 2.0 [ACH]	-29.70 % +59.40 %

Table 3: Infiltration Influence Coefficients

These results indicate that there still may appreciable error associated with the infiltration estimation for the winter design day. This could possibly affect the system design and the sizing of the boiler used to supply the system. Since the emphasis of the study is on the cooling load and chiller or thermal storage options, infiltration in the summer design day is less significant.

Building 390 Model

Building 390 at Rock Island Arsenal is a four story building with a basement that contains office space. The building is shaped like an H. The building was modeled as one zone per floor with a system serving each zone. The basement was zone 1 and the 4th floor was zone 5. Building 390 has a Multizone fan system cooling the entire building with installed 112,820 CFM. The scheduled loads with the envelope loads and outside air for ventilation for the simulation needed ~112,500 CFM to meet the loads and was used as the benchmark for the simulation. The assumed design conditions for Building 390 are:

People were assigned at 1 person per 150 Ft^2

Lighting was assumed at 1.2 W/ft^2 for a poorly lit office building.

Infiltration was not specified due to the fact that this building had storm windows installed.

Equipment Loads (W/ft^2) are specified for office areas at an amount of 2 W/ft^2.

An in-depth study was done for Building 350 because less determinate information was known about the building, and the loading on this building was the more significant portion with the computer rooms. For Building 390 the installed system CFM was known and this was used to base the simulation results for the coil loads. With this benchmark achieved we were confident of the loading in this building.

Weather File Summary for Moline, IL

This is statistical information for the weather file that was used in the hourly, annual BLAST simulation.

```
Weather File:  MOLINE/QUAD CITY, IL
   Latitude:  41.45 Longitude:   90.52 Time Zone:  6.0

 ** Year 1979   6263.2  Heating Degree Days    874.0 Cooling Degree Days

 Maximum Temperature Day Occurred on 30 May  High values, Drybulb=   93.92  Coincident Wetbulb=  72.60
  Low Drybulb=  68.00  Wind Speed (Avg)=    1471.5 Wind Direction= 233.7
  Barometric Pressure=    395.61  Total Horizontal=    2367.09  Clearness (Avg)=     0.912

 Minimum Temperature Day Occurred on  1 Jan  High values, Drybulb=   26.06  Coincident Wetbulb=  21.88
  Low Drybulb= -19.66  Wind Speed (Avg)=     776.7 Wind Direction= 133.3
  Barometric Pressure=    402.99  Total Horizontal=     256.15  Clearness (Avg)=     0.320
```

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Avg. Temp. (F) (Drybulb)	21.6	25.5	36.8	51.0	60.5	70.6	73.9	72.9	65.0	53.4	41.0	29.1
Avg. Temp. (F) (Wetbulb)	18.8	23.3	31.6	43.5	52.9	61.7	65.9	65.1	57.4	45.7	36.6	25.8
Avg. Daily Max Temp.	29.8	34.2	45.7	61.6	70.4	81.3	83.8	83.1	74.9	64.6	49.7	36.5
Avg. Daily Min Temp.	13.5	16.8	27.9	40.4	50.6	59.9	64.0	62.7	55.1	42.2	32.3	21.7
Avg. Daily Range	16.3	17.4	17.7	21.2	19.8	21.4	19.8	20.3	19.8	22.4	17.4	14.8
Maximum Temperature (F)	54.1	48.9	71.1	80.1	93.9	93.9	93.9	91.9	82.9	78.1	73.9	67.3
Minimum Temperature (F)	-19.7	-9.9	12.0	25.0	35.1	42.1	52.0	51.1	42.1	24.1	15.1	5.0
# Days Max 90. and Above					2	4	1	6				
# Days Max 32. and Below	18	9	2								3	10
# Days Min 32. and Below	29	25	25	6						6	18	25
# Days Min 0. and Below	9	3										
Avg. Wind Speed (Ft / Min)	930.7	1130.9	1135.3	1177.6	938.6	656.3	591.8	471.9	753.1	869.4	992.6	989.8
Avg. Wind Speed (Day)	1019.0	1251.7	1244.8	1354.6	1121.9	846.9	758.1	613.7	904.4	975.7	1095.6	1089.4
Avg. Wind Speed (Night)	842.4	1010.1	1025.7	1000.6	755.3	465.7	425.4	330.1	601.8	763.1	889.7	890.3
Avg. Wind Direction	191.3	177.8	177.8	188.7	162.0	168.6	164.1	129.4	157.4	188.1	196.5	191.2
Avg. Temp. (Day)	24.7	28.2	40.5	54.6	64.1	75.5	77.7	76.6	68.6	57.3	44.0	31.1
Avg. Temp. (Night)	20.1	23.7	33.5	47.4	57.4	64.7	68.3	67.6	61.2	50.7	38.6	28.0
Avg. Radiation	505.3	811.2	1138.0	1473.7	1712.1	1984.4	1914.5	1679.5	1350.6	1003.7	612.5	481.4
Avg. Clearness	0.61	0.64	0.71	0.70	0.71	0.71	0.71	0.69	0.71	0.70	0.64	0.65
Avg. Pressure	402.3	401.5	398.8	398.4	398.3	399.5	398.7	400.1	400.3	401.7	399.7	399.6
Avg. Rel. Hum. at 4am	90.1	93.8	90.5	86.4	88.3	86.4	90.4	93.3	89.2	86.3	90.4	89.7
10am	88.3	88.9	79.2	71.8	72.6	67.9	68.3	70.4	75.5	74.3	85.8	85.8
4pm	87.8	89.0	75.4	68.8	67.7	64.1	67.4	67.6	68.2	68.7	80.2	83.8
10pm	89.2	92.5	86.1	81.0	82.1	83.5	86.4	87.6	84.7	82.4	87.8	88.4

Monthly Average Temperatures as a Function of Hour of the Day

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	20.2	23.8	32.8	46.3	56.9	63.7	67.5	66.6	59.8	48.8	37.9	27.6
1	19.8	23.1	32.0	45.4	55.3	62.7	66.8	65.6	59.3	48.2	37.5	27.7
2	19.2	22.2	31.4	44.6	54.2	61.8	65.8	64.8	58.7	47.6	37.1	27.6
3	18.8	21.5	31.2	44.1	53.3	62.3	65.1	64.4	58.3	47.1	36.7	27.3
4	18.3	21.2	30.7	43.6	52.4	62.9	65.0	64.0	57.9	46.6	36.4	27.0
5	17.5	21.0	30.3	43.0	52.4	63.6	66.2	64.4	57.7	46.2	36.1	26.3
6	18.6	20.8	31.2	45.3	53.8	66.9	69.0	67.2	57.7	45.7	35.8	26.4
7	19.1	21.8	34.0	48.1	57.2	70.2	71.9	70.4	60.3	48.6	37.2	26.9
8	19.5	23.8	36.5	50.8	60.1	73.6	74.7	73.8	62.9	51.3	38.5	27.2
9	21.4	25.8	38.7	53.0	62.5	75.3	77.4	76.4	65.6	54.2	39.8	28.2
10	23.2	27.7	40.3	54.9	64.8	77.1	79.9	78.5	68.1	56.8	42.1	30.0
11	25.0	28.8	41.6	56.9	66.7	78.8	81.4	79.7	70.5	59.4	44.4	31.6
12	25.8	30.3	43.1	57.7	67.5	79.5	82.2	80.7	72.7	62.1	46.6	32.9
13	26.5	30.9	44.1	58.4	68.4	80.1	82.9	81.7	73.4	62.6	47.2	33.5
14	27.2	30.8	44.2	59.1	69.3	80.7	82.7	82.1	74.1	63.2	47.8	33.9
15	26.2	30.4	43.7	58.6	69.3	80.0	82.4	81.7	74.3	63.8	48.4	33.5
16	25.0	29.2	42.6	58.1	69.0	79.3	81.7	80.6	72.6	61.4	46.2	32.0
17	23.8	28.1	40.9	57.6	68.2	78.5	80.8	79.4	70.9	59.0	44.0	30.4
18	23.1	27.0	39.0	55.6	67.4	75.1	77.8	76.0	69.1	56.5	41.9	29.3
19	22.7	26.5	37.5	53.4	64.3	71.8	73.8	73.4	66.7	54.9	41.0	28.9
20	21.9	26.0	36.2	51.2	61.4	68.4	71.8	71.4	64.2	53.3	40.3	28.4
21	21.7	25.5	35.3	50.1	60.1	67.4	70.4	69.8	62.2	51.6	39.5	28.0
22	21.3	24.7	34.2	49.1	58.8	66.4	69.5	68.7	61.2	50.7	39.0	27.7
23	20.7	24.6	33.8	48.0	57.5	65.4	68.3	67.8	60.2	49.6	38.4	27.4

Following Design Temperatures based on Normal Spans
Jun-Sep for Summer, Dec-Feb for Winter
Design Temperatures ------------------------------------- Summer ---------- Winter ---------

Per Cent	Summer T(Dry)	Summer Coinc T(Wet)	Winter T(Dry)	Winter Coinc T(Wet)
1.0	92.	75.	-10.	-12.
2.5	91.	74.	-7.	-9.
5.0	89.	74.		

Following Design Temperatures based on Single Months
Jul for Summer, Jan for Winter
Design Temperatures ------------------------------------- Summer ---------- Winter ---------

Per Cent	Summer T(Dry)	Summer Coinc T(Wet)	Winter T(Dry)	Winter Coinc T(Wet)
1.0	91.	78.	-13.	-15.
2.5	90.	77.	-10.	-12.
5.0	88.	75.		

Winter (Lowest) Temperatures

Temp	Dec-Feb Hours	Jan Hours
-19	1	1
-13	2	2
-12	3	3
-11	2	2
-10	1	1
-9	5	2
-8	7	2
-7	3	1
-6	7	5
-5	6	4

Summer (Highest) Temperatures

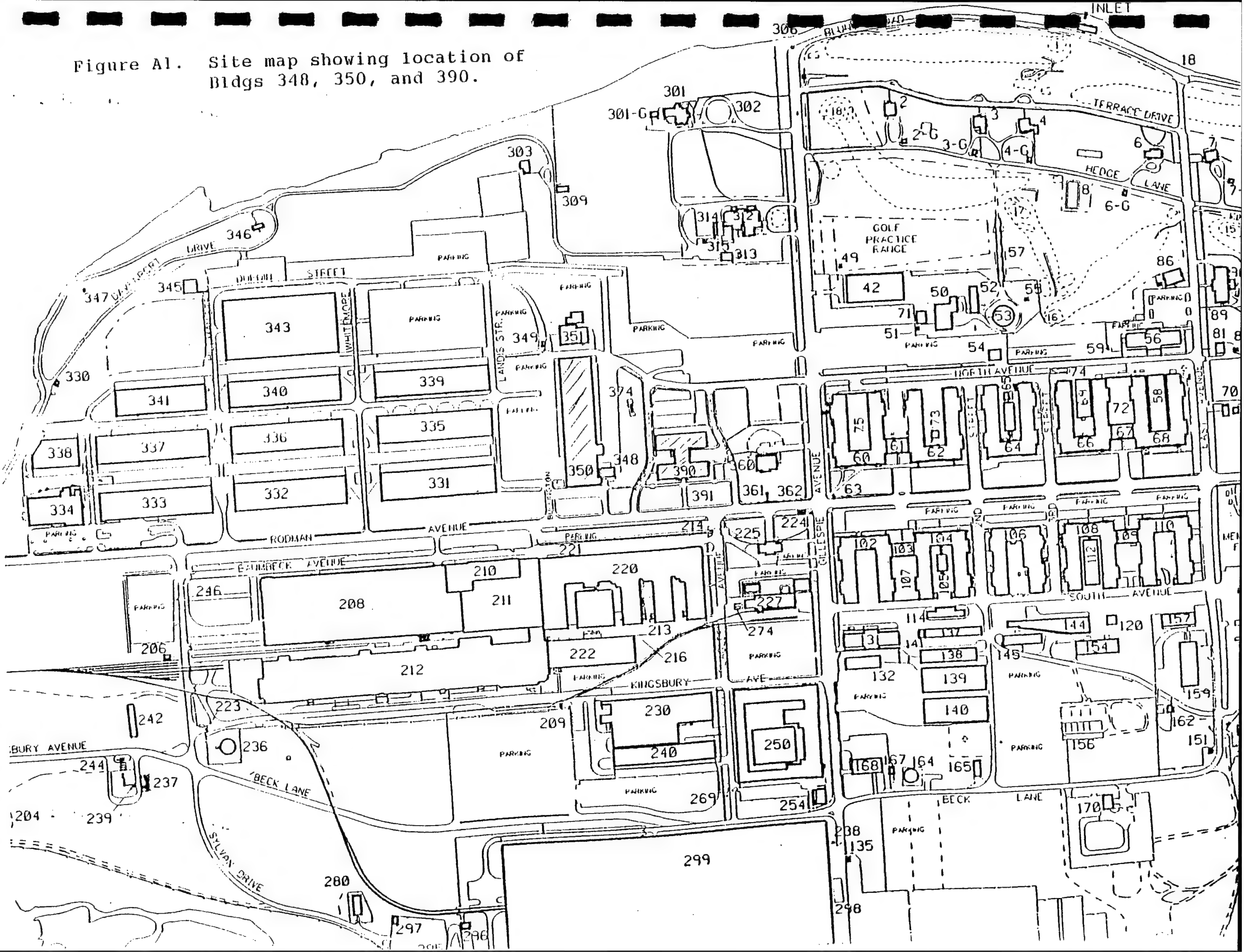
Temp	Jun-Sep Hours	Jul Hours
94	2	1
93	8	1
92	7	1
91	21	1
90	25	5
89	30	3
88	29	12
87	35	11
86	46	16
85	45	21

Conclusion

The system coil loads for Building 350 and 390 were used for the plant recommendations for Chiller, Thermal Storage analysis done by Dr. Chang Sohn. The building material properties were obtained from the "GARD Study" done a few years ago for the entire arsenal. Included on a 3.5 inch floppy disk are the BLAST input and output files associated with each building.

Appendix B

Figure A1. Site map showing location of Bldgs 348, 350, and 390.



Appendix B contains information obtained during site visits to the Rock Island Arsenal. Figure A1 is a partial map of the Rock Island Arsenal which identifies Bldgs 350, 390, and 348. The remainder of the figures in this appendix are photographs of buildings and cooling equipment taken during site visits. Figure A2 shows Bldg 350 with electric chillers and other cooling equipment on the dock. Figure A3 is a similar view of Bldg 350. Also identified in the photograph is the parking lot adjacent to the dock and Bldg 348, shown on the left of the picture. Figures A4 and A5 show dry coolers which are located on the dock of Bldg 350. Figure A6 is a photograph of Bldg 390. Figure A7 is a photograph of a nameplate of one of the electric chillers located on the dock of Bldg 350. Figure A8 is a photograph of the 750 ton absorption chiller in Bldg 348. Figure A9 shows Bldg 348 on the left side of the picture and its relationship to Bldg 350, located in the background.

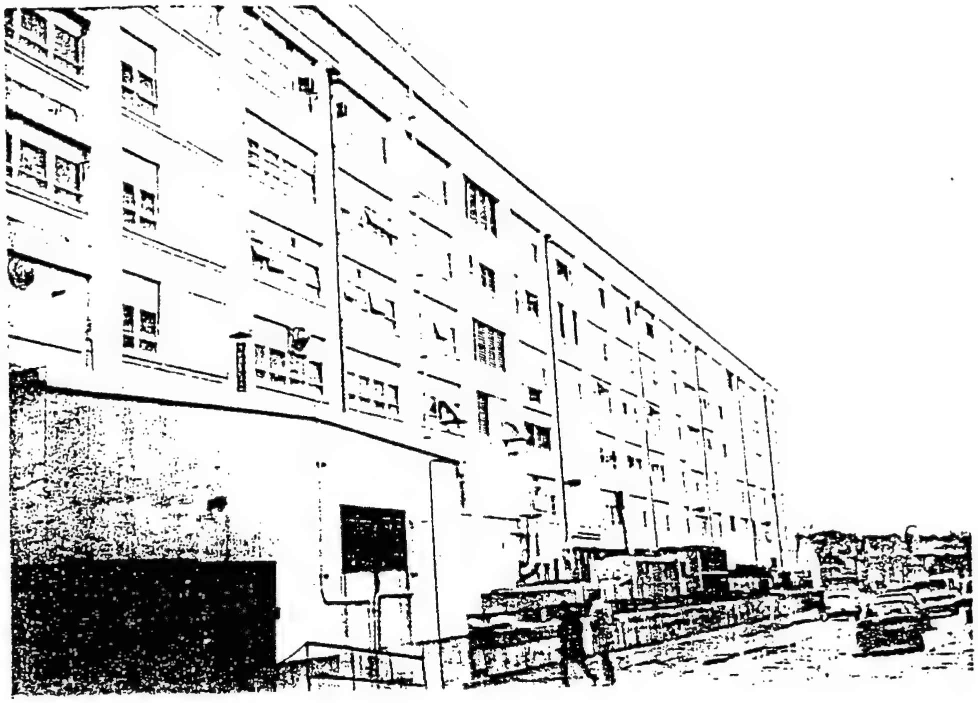


Figure A2. Bldg 350 showing cooling equipment on dock.

Figure A3. Bldg 350 showing cooling equipment on dock.

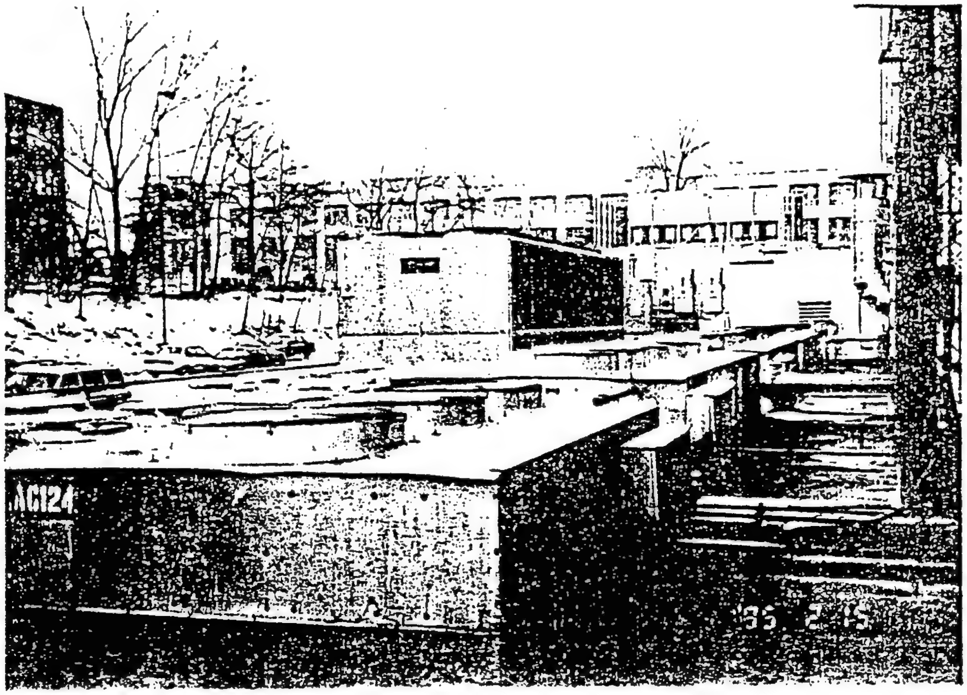


Figure A4. Dry coolers on the dock of Bldg 350.

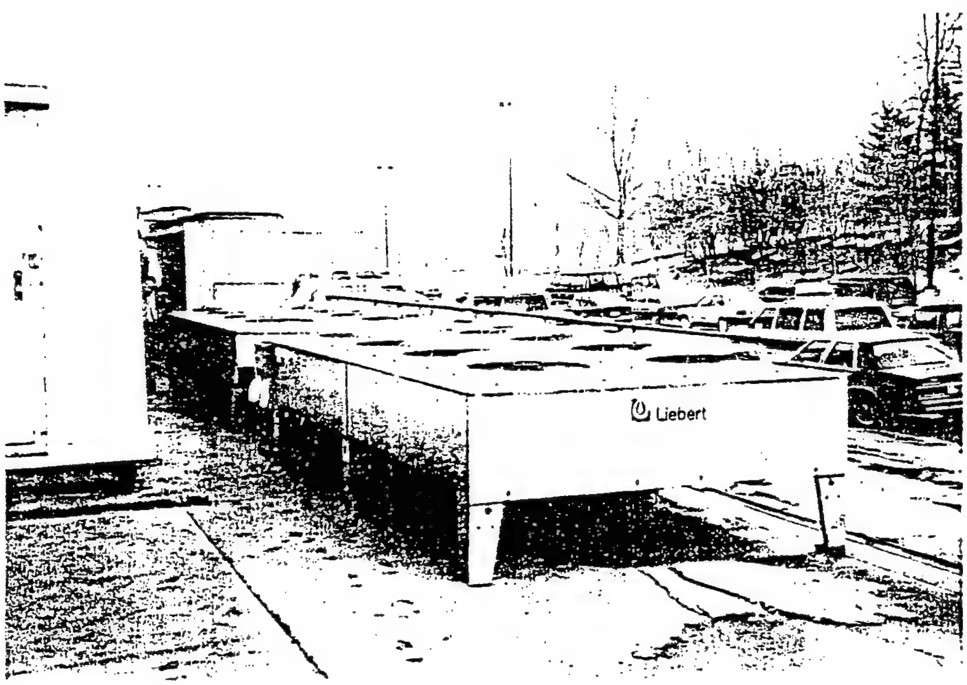


Figure A5. Dry coolers on the dock of Bldg 350.

Figure A6. Bldg 390.

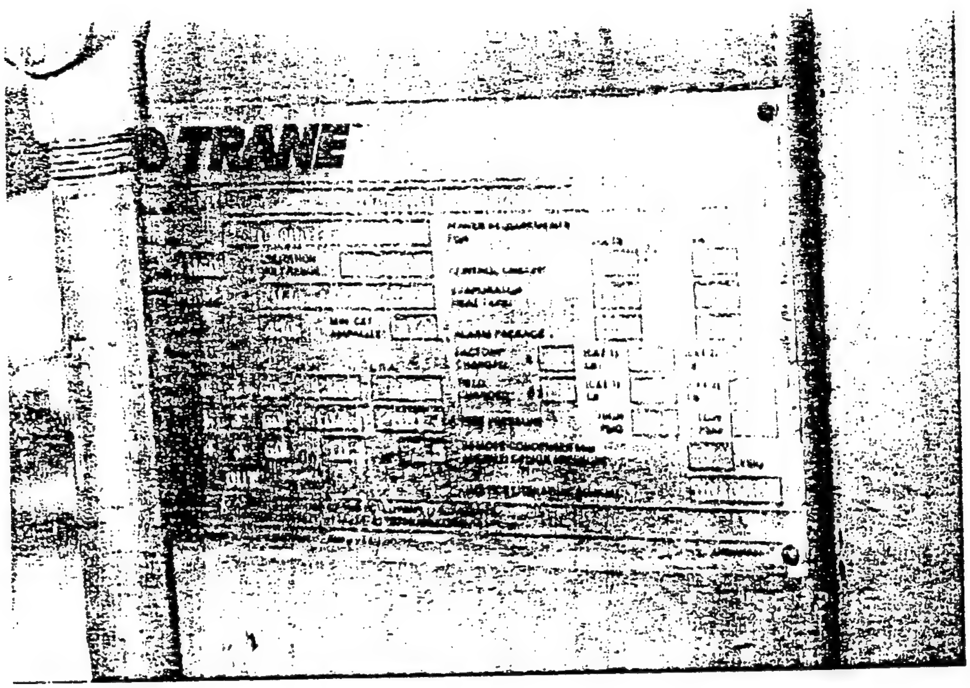


Figure A7. Nameplate of electric chiller located on the dock of Bldg 350.

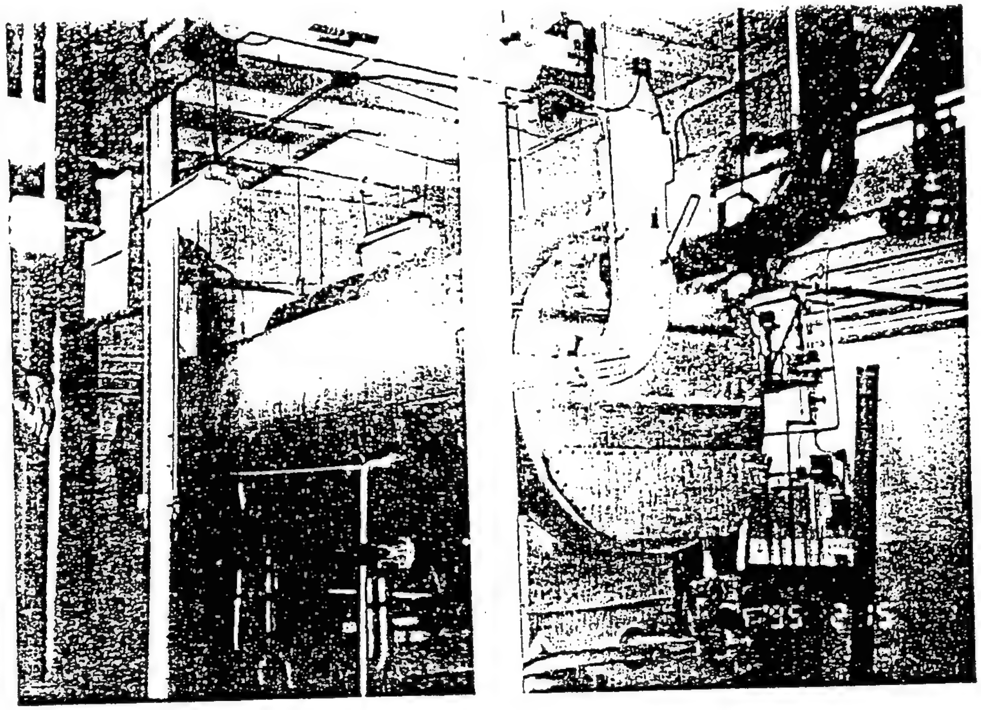


Figure A8. 750 ton absorption chiller in Bldg 348.

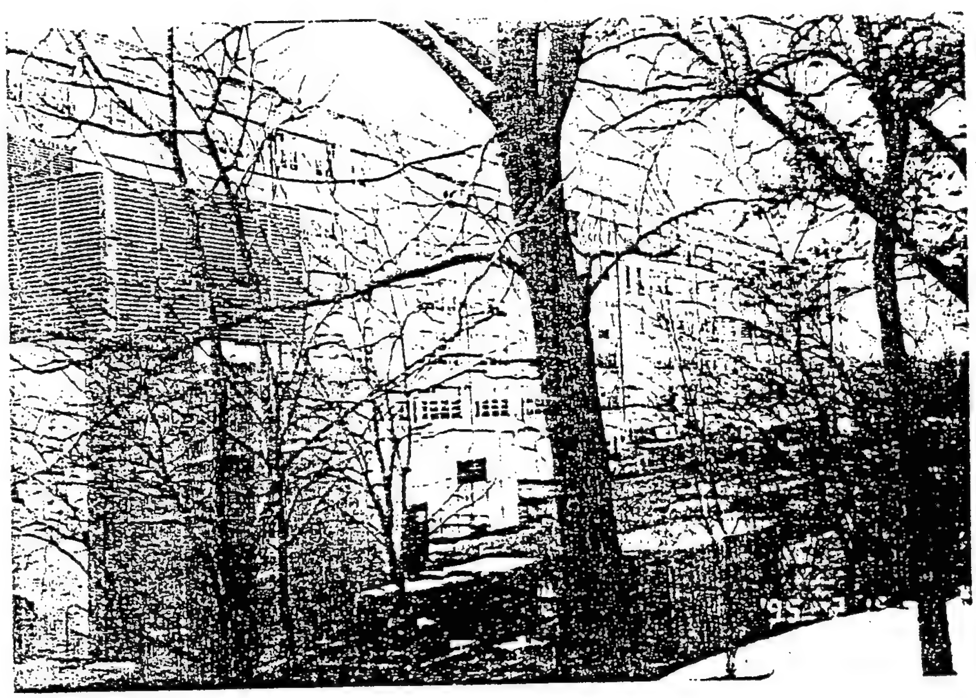


Figure A9. Bldg 348 (on left) and Bldg 350 (in background).

Appendix C

RATE NO. 53 LARGE INDUSTRIAL ELECTRIC SERVICE

Available for service supplied at a single point of delivery to any industrial customer for power, lighting, or other uses in connection with manufacturing and processing.

NET MONTHLY RATE:

Basic Service:

$540 per month

Billing Demand Charge:

	Summer	Winter
All kW	$10.55 per kW	$5.75 per kW

Energy Charge: (Subject to fuel cost adjustment and nuclear decommissioning factor)

	Summer	Winter
On Peak - All kilowatthours	3.47¢ per kWh	3.47¢ per kWh
Off Peak - All kilowatthours	2.14¢ per kWh	2.14¢ per kWh

Summer - Applicable during the four monthly billing periods of June through September.
Winter - Applicable during the eight monthly billing periods of October through May.

On Peak Hours - Daytime periods between 8:00 a.m. and 8:00 p.m. Monday through Friday during the month excluding the United States legal holidays of New Year's Day, Memorial Day, Independence Day, Labor Day, Thanksgiving Day, and Christmas Day.
Off Peak Hours - All hours not included in the definition of On Peak Hours.

Minimum Charge:

The minimum monthly bill shall be the basic service charge, applicable energy charges for the month, and billing demand charges for the month. No minimum monthly charge shall be less than a demand charge applicable for a billing demand of 10,000 kilowatts.

REACTIVE DEMAND CHARGE:

A reactive demand charge shall be made for each kilovar by which the customer's maximum reactive demand in kilovars is

(Continued on Sheet No. 10.10)

Appendix D

FEASIBILITY REPORT ON STORAGE COOLING SYSTEMS

***** PROJECT DESCRIPTION *****

PROJECT TITLE: Bldgs 350 & 390
PROJECT LOCATION: Rock Island, IL
PROJECT YEAR: FY95
PROJECT NUMBER: N/A
CAT CODE: N/A
DESIGNER: B. Boughton
DATE: 05-10-1995

***** INPUT DATA *****

STUDY LIFE : 10yrs DISCOUNT RATE : 4%

***** ELECTRIC UTILITY RATE STRUCTURE *****

--- TOU DEMAND (TWO DEMAND CHARGES) ---

DEMAND CHARGE ($/kW) IN SUMMER: 10.55000
DEMAND CHARGE ($/kW) IN WINTER: 5.75000
ON-PEAK : 0.03470 OFF-PEAK : 0.02140

***** WINDOW SIZE FOR SHIFTED POWER PERCENTAGE ****

1- 3%	4- 6%	7- 9%	10- 12%	13- 15%	16- 18%	19- 21%	22- 24%
4 hr	6 hr	8 hr	8 hr	8 hr	8 hr	8 hr	8 hr

***** ELECTRIC UTILITY DATA *****

YEARLY PEAK DEMAND (kW): 20,800.00
UTILITY INCENTIVE ($/kW): 0.00

***** SYSTEM FIRST COST MODEL *****

NEW/REPLACEMENT ($/ton-hr)	RETROFIT ($/ton-hr)	UPPER LIMIT ($/ton-hr)
80	150	300

***** ECONOMY OF SCALE FOR FIRST COST *****

Small(<1000 t-h)	Medium	Large(>10kt-h)
1	.87	.77

***** SYSTEM O&M COST MODEL *****

PERCENT OF SYSTEM FIRST COST(%)
0

***** EXPECTED ANNUAL DEMAND CHARGE ESCALATION RATE *****

1	2	3	4	5	(YEAR)
.3353	-1.8682	.408	.2709	1.1475	(%)
6	7	8	9	10	(YEAR)
.6677	.1326	.7281	1.0521	.911	(%)
11	12	13	14	15	(YEAR)
.3869	.3207	.3207	.1276	.8282	(%)
16	17	18	19	20	(YEAR)
.6113	.6133	.617	.6198	.6225	(%)
21	22	23	24	25	(YEAR)
.626	.6294	.5891	.5928	.5966	(%)

***** New/Replacement *****

Shift (%)	Shifted (kW)	Storage Sz(ton-hr)	System 1st Cst(1000$)	1st yr Svns(1000$)	Payback Smpl	Payback Dsct	SIR	Net Svng (1000$)
1	208	832	67	19	3.6	4.0	2.1	72
2	416	1,664	116	37	3.1	4.0	2.4	161
3	624	2,496	174	56	3.1	4.0	2.4	242
4	832	4,992	347	75	4.6	6.0	1.6	211
5	1,040	6,240	434	94	4.6	6.0	1.6	267
6	1,248	7,488	521	113	4.6	6.0	1.6	323
7	1,456	11,648	718	133	5.4	7.0	1.4	274
8	1,664	13,312	820	153	5.4	7.0	1.4	319
9	1,872	14,976	923	173	5.3	7.0	1.4	364
10	2,080	16,640	1,025	192	5.3	7.0	1.4	409
11	2,288	18,304	1,128	212	5.3	7.0	1.4	454
12	2,496	19,968	1,230	232	5.3	7.0	1.4	499
13	2,704	21,632	1,333	252	5.3	7.0	1.4	545
14	2,912	23,296	1,435	271	5.3	7.0	1.4	590
15	3,120	24,960	1,538	291	5.3	7.0	1.4	635
16	3,328	26,624	1,640	311	5.3	7.0	1.4	680
17	3,536	28,288	1,743	331	5.3	7.0	1.4	725
18	3,744	29,952	1,845	351	5.3	7.0	1.4	770
19	3,952	31,616	1,948	370	5.3	7.0	1.4	815
20	4,160	33,280	2,050	390	5.3	7.0	1.4	860
21	4,368	34,944	2,153	410	5.3	7.0	1.4	905
22	4,576	36,608	2,255	430	5.2	7.0	1.4	950
23	4,784	38,272	2,358	449	5.2	7.0	1.4	995
24	4,992	39,936	2,460	469	5.2	7.0	1.4	1,040
25	5,200	41,600	2,563	489	5.2	7.0	1.4	1,085

* Annual O&M Cost is assumed to be 0% of system cost.

***** Retrofit Case *****

Shift (%)	Shifted (kW)	Storage Sz(ton-hr)	System 1st Cst(1000$)	1st yr Svns(1000$)	Payback Smpl	Payback Dsct	SIR	Net Svng (1000$)
1	208	832	125	19	6.7	8.0	1.1	14
2	416	1,664	217	37	5.8	7.0	1.3	60
3	624	2,496	326	56	5.8	7.0	1.3	90
4	832	4,992	651	75	8.7	**.*	0.9	-93
5	1,040	6,240	814	94	8.7	**.*	0.9	-113
6	1,248	7,488	977	113	8.6	**.*	0.9	-133
7	1,456	11,648	1,345	133	10.1	**.*	0.7	-353
8	1,664	13,312	1,538	153	10.1	**.*	0.7	-398
9	1,872	14,976	1,730	173	10.0	**.*	0.7	-443
10	2,080	16,640	1,922	192	10.0	**.*	0.7	-487
11	2,288	18,304	2,114	212	10.0	**.*	0.7	-532
12	2,496	19,968	2,306	232	9.9	**.*	0.7	-577
13	2,704	21,632	2,498	252	9.9	**.*	0.8	-621
14	2,912	23,296	2,691	271	9.9	**.*	0.8	-666
15	3,120	24,960	2,883	291	9.9	**.*	0.8	-711
16	3,328	26,624	3,075	311	9.9	**.*	0.8	-755
17	3,536	28,288	3,267	331	9.9	**.*	0.8	-800
18	3,744	29,952	3,459	351	9.9	**.*	0.8	-845
19	3,952	31,616	3,652	370	9.9	**.*	0.8	-889
20	4,160	33,280	3,844	390	9.9	**.*	0.8	-934
21	4,368	34,944	4,036	410	9.8	**.*	0.8	-979
22	4,576	36,608	4,228	430	9.8	**.*	0.8	-1,023
23	4,784	38,272	4,420	449	9.8	**.*	0.8	-1,068
24	4,992	39,936	4,613	469	9.8	**.*	0.8	-1,113
25	5,200	41,600	4,805	489	9.8	**.*	0.8	-1,157

* Annual O&M Cost is assumed to be 0% of system cost.

***** Upper Limit Case *****

Shift (%)	Shifted (kW)	Storage Sz(ton-hr)	System 1st Cst(1000$)	1st yr Svns(1000$)	Payback Smpl	Payback Dsct	SIR	Net Svng (1000$)
1	208	832	250	19	13.4	**.*	0.6	-111
2	416	1,664	434	37	11.7	**.*	0.6	-157
3	624	2,496	651	56	11.7	**.*	0.6	-236
4	832	4,992	1,303	75	17.4	**.*	0.4	-745
5	1,040	6,240	1,629	94	17.3	**.*	0.4	-927
6	1,248	7,488	1,954	113	17.3	**.*	0.4	-1,110
7	1,456	11,648	2,691	133	20.2	**.*	0.4	-1,699
8	1,664	13,312	3,075	153	20.1	**.*	0.4	-1,936
9	1,872	14,976	3,459	173	20.0	**.*	0.4	-2,173
10	2,080	16,640	3,844	192	20.0	**.*	0.4	-2,409
11	2,288	18,304	4,228	212	19.9	**.*	0.4	-2,646
12	2,496	19,968	4,613	232	19.9	**.*	0.4	-2,883
13	2,704	21,632	4,997	252	19.9	**.*	0.4	-3,120
14	2,912	23,296	5,381	271	19.8	**.*	0.4	-3,357
15	3,120	24,960	5,766	291	19.8	**.*	0.4	-3,594
16	3,328	26,624	6,150	311	19.8	**.*	0.4	-3,831
17	3,536	28,288	6,535	331	19.8	**.*	0.4	-4,067
18	3,744	29,952	6,919	351	19.7	**.*	0.4	-4,304
19	3,952	31,616	7,303	370	19.7	**.*	0.4	-4,541
20	4,160	33,280	7,688	390	19.7	**.*	0.4	-4,778
21	4,368	34,944	8,072	410	19.7	**.*	0.4	-5,015
22	4,576	36,608	8,456	430	19.7	**.*	0.4	-5,252
23	4,784	38,272	8,841	449	19.7	**.*	0.4	-5,488
24	4,992	39,936	9,225	469	19.7	**.*	0.4	-5,725
25	5,200	41,600	9,610	489	19.6	**.*	0.4	-5,962

* Annual O&M Cost is assumed to be 0%   of system cost.

Appendix E

THRALL DISTRIBUTION

QUOTATION

Date 6-19-95

Quotation Number

PEORIA DIVISION
8515 N. University Street
Peoria, IL 61615

1-800-873-4320
(309) 692-9550
FAX (309) 692-9887

Job or Inquiry Number

U.S.A. CERL

CHAMPAIGN, IL

ATTN: DOUG ANDERSON

PHONE 217-398-5513
FAX 217-373-3430

Item No.	Quantity	Description	Price	Unit	Total
		WE ARE PLEASED TO QUOTE THE FOLLOWING BUDGET PRICING ONLY FOR CHILLED WATER APPLICATION			
		APPLICATION A 1280 GPM @ 60 TDH			
	1 PC	PEERLESS F21050AM-BF 5 X 6-10 CAST IRON BRONZE FITTED END SUCTION CENTRIFUGAL PUMP MOUNTED ON A FABRICATED STEEL BASE TO A FACTORY CHOICE 25 HP, 1750 RPM, 460 V, 3 PH TEFC STD. EFFICIENCY MOTOR. UNIT TO HAVE WOODS COUPLING & CALIFORNIA COUPLING GUARD.	2355.00	EA	
		APPLICATION B 430 GPM @ 60 TDH			
	1 PC	PEERLESS F11030AM-BF 3 X 4-10 CAST IRON BRONZE FITTED END SUCTION CENTRIFUGAL PUMP MOUNTED ON A FABRICATED STEEL BASE TO A FACTORY CHOICE 10 HP, 1750 RPM, 460 V, 3 PH TEFC STD. EFFICIENCY MOTOR. UNIT TO HAVE WOODS COUPLING & CALIFORNIA COUPLING GUARD.	1585.00	EA	

Terms	F.O.B.	Person Quoting	Salesman
NET 30 DAYS	FACTORY	DAVE REAKTENWALT	

We submit for your consideration this proposal, subject to the following conditions: (1) final prices will be those generally in effect at time of shipment (2) we reserve the right to correct any clerical or typographical errors (3) any applicable sales, use, excise or other taxes will be added to the price (4) we do not guarantee descriptions, sizes, models or quantities to be in exact conformance with any particular plans or specifications (5) we shall not be liable for any loss any damage for delay in delivery or for non-delivery when the same is not due to our own negligence (6) this proposal is valid for only thirty (30) days from date during which time we must receive your acceptance in the form of a firm order on the terms herein set forth.

END SUCTION GENERAL PURPOSE PUMPS
Series F — Frame Mounted — Steel Base

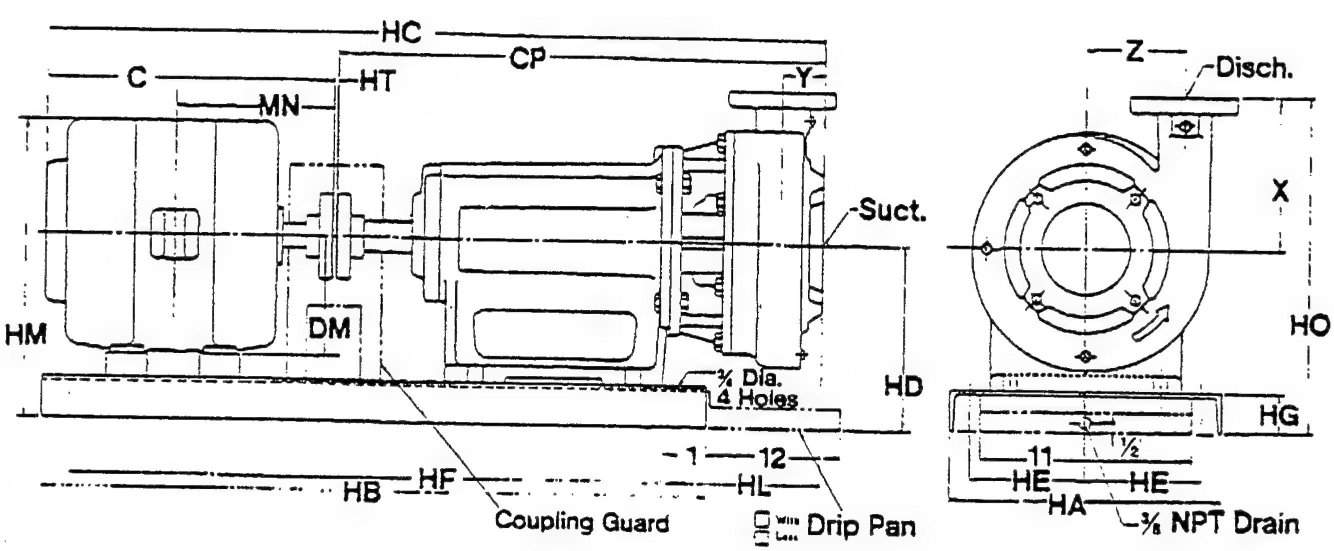
Peerless Pump Company
A member of the Sterling Group

Series, Type, Style
~~F21240AM, F21240AP~~
F21250AM, ~~F21250AP~~

Note 1: Customer must fill base with grout and allow for .75 to 1.50 inch grout thickness between top of foundation and bottom of base

Note 2: Unit Installation and final coupling alignment must be done by the installing contractor per Peerless Pump Company Installation Bulletin 2880549.

Unit Outline



✓	Pump Series, Type, Style	Suction (Equivalent to 125 Lb. ANSI Flange)	Discharge 125 Lb. ANSI Flange	X	Y	Z	CP	HL	BARE PUMP Weight Lbs.
	DIMENSIONS IN INCHES								
	PUMP							MTG.	
	F21240AM	5	4	9.00	2.44	7.50	20.88	8.44	207
	F21240AP	5	4	9.00	2.44	7.50	23.62	11.19	214
X	F21250AM	6	5	9.38	3.50	8.00	22.12	9.88	232
	F21250AP	6	5	9.38	3.50	8.00	24.88	12.44	238

✓	Motor Frame	F21240AM HC* Max.	F21240AM HO	F21240AP HC* Max.	F21240AP HO	F21250AM HC* Max.	F21250AM HO	F21250AP HC*	F21250AP	C* Max.	DM	HA	HB	HD	HE	HF	HG	HM Max.*	HT	MN	Unit with ODP Motor F2 1240A	Unit with ODP Motor F2 1250A	Add for TEFC Motor
	215T	42.12	18.38	44.88	18.38	—	—	—	—	21	5.25	12	31	9.38	4.5	29	3.00	10.38	.25	10.38	485	—	—
	254T	45.12	18.75	47.88	18.75	—	—	—	—	24	6.25	15	36	9.76	8.0	34	3.38	16.00	.25	12.38	565	—	—
	256T	47.12	18.75	49.88	18.75	—	—	—	—	26	6.25	15	36	9.75	6.0	34	3.38	17.75	.25	13.25	588	—	25
X	284T	48.12	20.12	50.88	20.12	49.38	20.50	52.12	20.50	27	7.00	18	40	11.12	7.5	38	4.00	19.12	.25	14.12	663	683	60
	286T	49.12	20.12	51.88	20.12	50.38	20.50	53.12	20.50	28	7.00	18	40	11.12	7.5	38	4.00	19.12	.25	14.88	718	748	80
	324T	51.12	21.12	53.88	21.12	52.38	21.50	55.12	21.50	30	8.00	18	40	12.12	7.3	38	4.00	21.12	.25	16.75	863	893	90
	326T	—	—	—	—	54.38	21.50	57.12	21.30	32	8.00	18	40	12.12	7.5	38	4.00	21.12	.25	16.50	—	968	90
	364T	—	—	—	—	57.12	22.50	59.88	22.50	34	9.00	18	44	13.12	7.3	42	4.00	22.75	1.0	17.38	—	988	125
	364TS	—	—	—	—	54.12	22.50	56.88	22.30	31	9.00	18	40	13.12	7.5	38	4.00	22.75	1.0	15.25	—	988	125

CUSTOMER U.S.A CERL
JOB NAME Cooling Tower Pump
P.O. NO.
ITEM NO.
S.O. NO.
SERIAL NO.
MOTOR MFR. EMERY ENCL. TEFC FRAME 284T
H.P. 25 VOLTS 480 PH. 3 HZ. 60
PUMP SERIES, TYPE, STYLE F21250AM
RPM 1750 G.P.M. 1280 TOTAL HD. FT. 60
CERTIFIED FOR ☐ APPROVAL ☐ CONSTRUCTION
BY DLR DATE 6-8-95

Subject to change unless certified for construction.

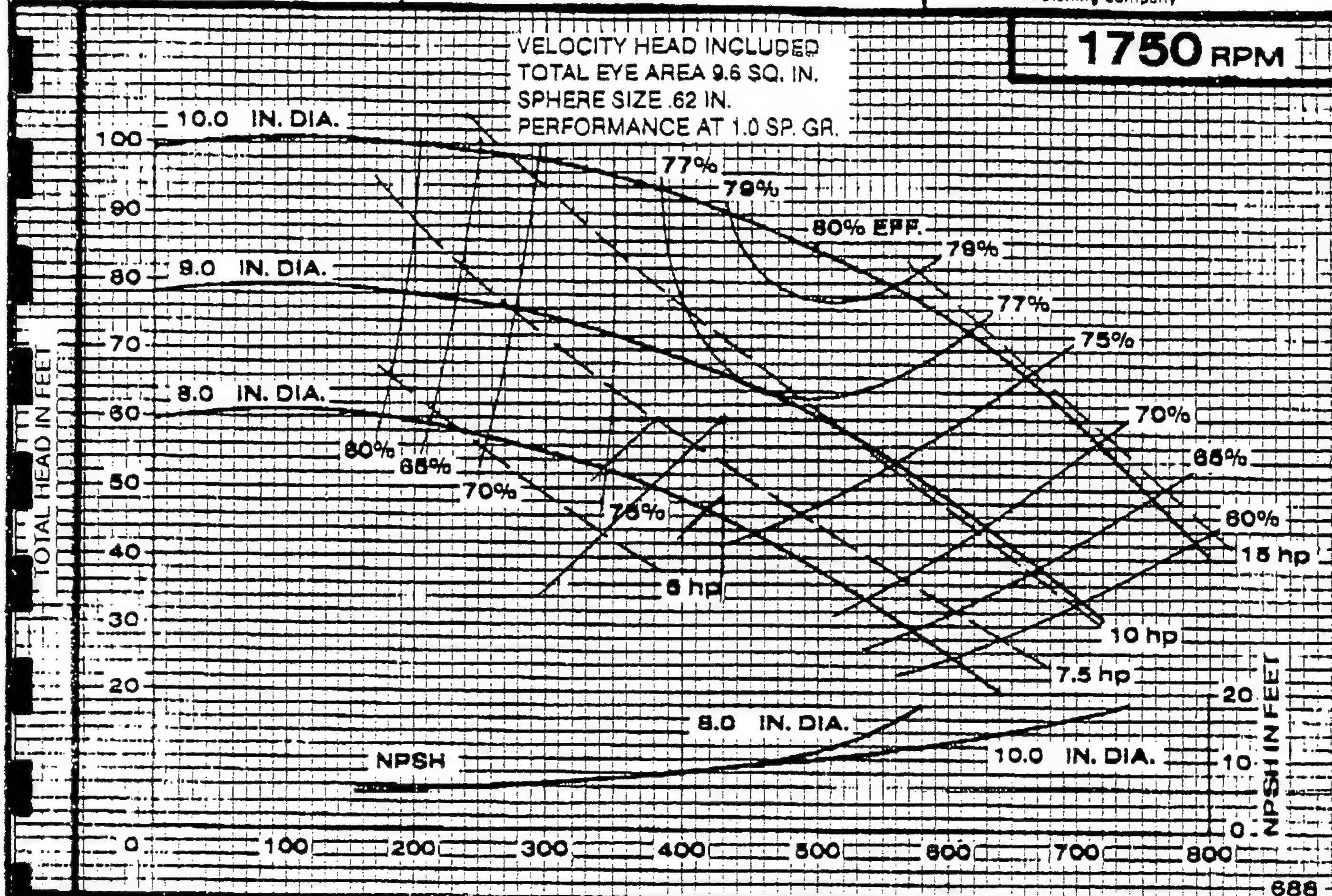
DT4852450
Rev. 5-92

SECTION 2340

END SUCTION PUMPS

Series C&F Type 1030A Size 3 x 4 x 10

Peerless Pump
A Sterling Company



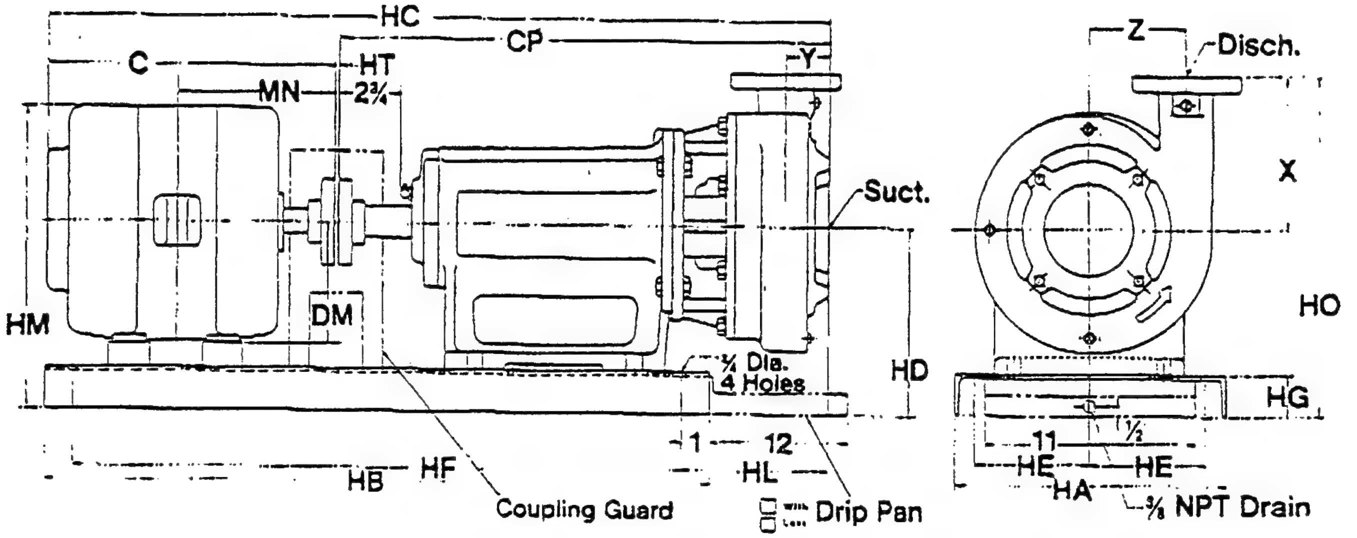
IMPELLER 2684315 | U.S. GALLONS PER MINUTE | CURVE 3115004

Peerless Pump
A Sterling Company

END SUCTION GENERAL PURPOSE PUMPS
Series F — Frame Mounted — Steel Base

Series, Type, Style
~~F11025AM, F11025AP~~
F11030AM, ~~F11030AP~~

UNIT OUTLINE



DIMENSIONS IN INCHES									
	PUMP							MTG.	BARE PUMP Weight Lbs.
✓	Pump Series, Type, Style	Suction (Equivalent to 125 Lb. ANSI Flange)	Discharge 125 Lb. ANSI Flange	X	Y	Z	CP	HL	
	F11025AM	3	2½	7.50	2.25	5.88	19.50	7.00	132
	F11025AP	3	2½	7.50	2.25	5.88	22.50	10.00	137
X	F11030AM	4	3	7.50	2.12	6.25	19.50	7.00	148
	F11030AP	4	3	7.50	2.12	8.25	22.50	10.00	153

SPECIFIC UNIT DIMENSIONS IN INCHES										COMMON DIMENSIONS IN INCHES											WEIGHT—LBS.		
	✓																				Unit with ODP Motor		Add for TEFC Motor
✓	Motor Frame	F11025AM		F11025AP		F11030AM		F11030AP		C* Max.	DM	HA	HB	HD	HE	HF	HG	HM Max.*	HT	MN	F1 1025A	F1 1030A	
		HC* Max.	HO	HC* Max.	HO	HC* Max.	HO	HC* Max.	HO														
	182T	34.25	15.88	37.25	15.88	34.25	15.88	37.25	15.88	14.50	4.50	12	37	8.38	4.5	29	3.00	13.25	.25	7.75	275	294	10
	184T	35.25	15.88	38.25	15.88	35.25	15.88	38.25	15.88	15.50	4.50	12	31	8.38	4.5	29	3.00	13.25	.25	8.25	289	308	10
X	213T	37.38	15.88	40.38	15.88	37.38	15.88	40.38	15.88	17.62	5.25	12	31	8.38	4.5	29	3.00	14.25	.25	9.82	348	387	20
	215T	38.88	15.88	41.88	15.88	38.88	15.88	41.88	15.88	19.12	5.25	12	31	8.38	4.5	28	3.00	14.25	.25	10.38	372	391	20
	254T	—	—	—	—	42.12	17.25	45.12	17.25	22.38	8.25	15	36	9.75	6.0	34	3.38	17.75	.25	12.38	—	482	25

*Maximum dimensions; may be less with different make motors or enclosures.

CUSTOMER U.S.A. CERL JOB NAME COOLING TOWER PUMP
P.O. NO. ITEM NO.
S.O. NO. SERIAL NO.
MOTOR MFR. FACTORY ENCL. TEFC FRAME 213T H.P. 20 VOLTS 480 PH. 3 HZ. 60
PUMP SERIES, TYPE, STYLE F11030 AM RPM 1750 G.P.M. 430 TOTAL HD. FT. 60
CERTIFIED FOR ☐ APPROVAL ☐ CONSTRUCTION BY DLD DATE 6-19-95

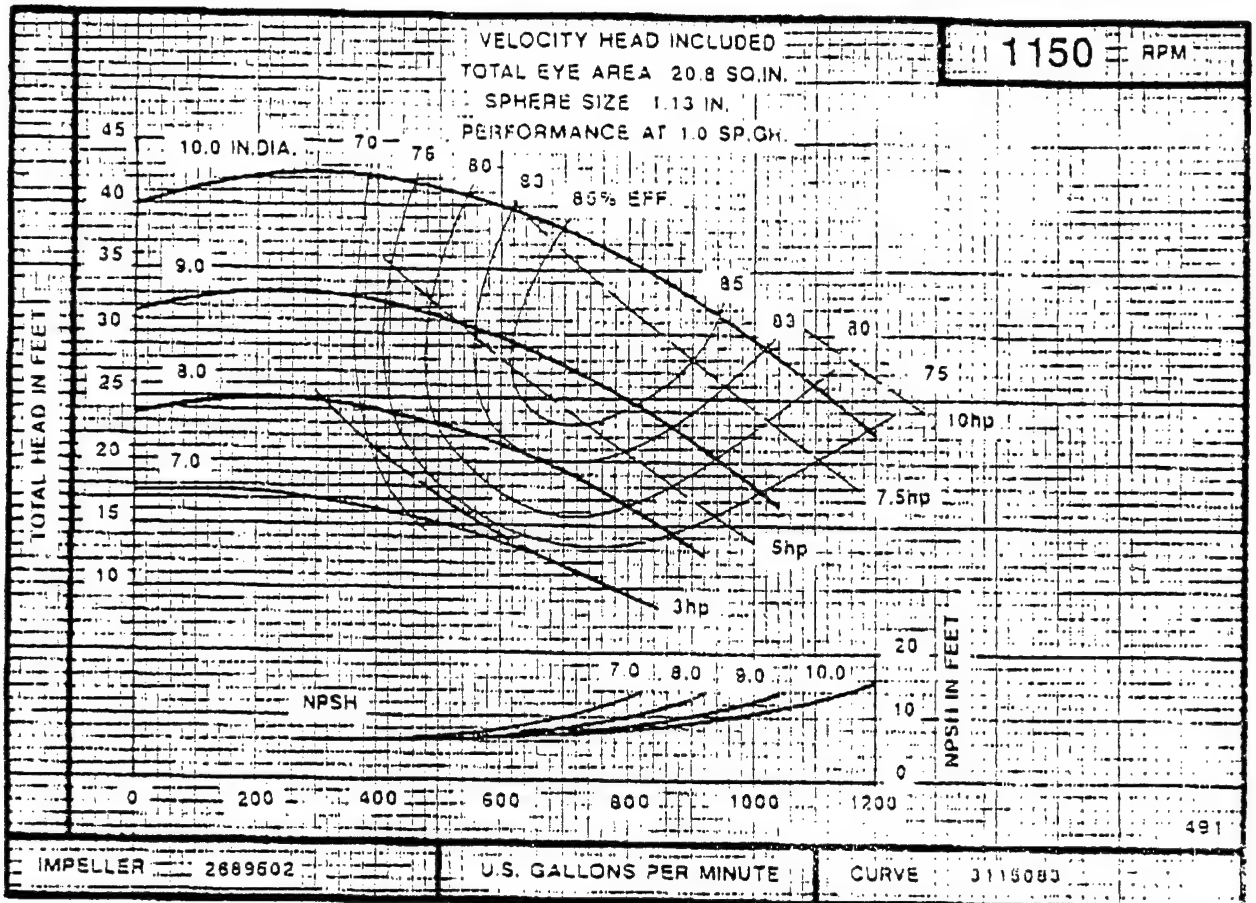
Subject to change unless certified for construction.

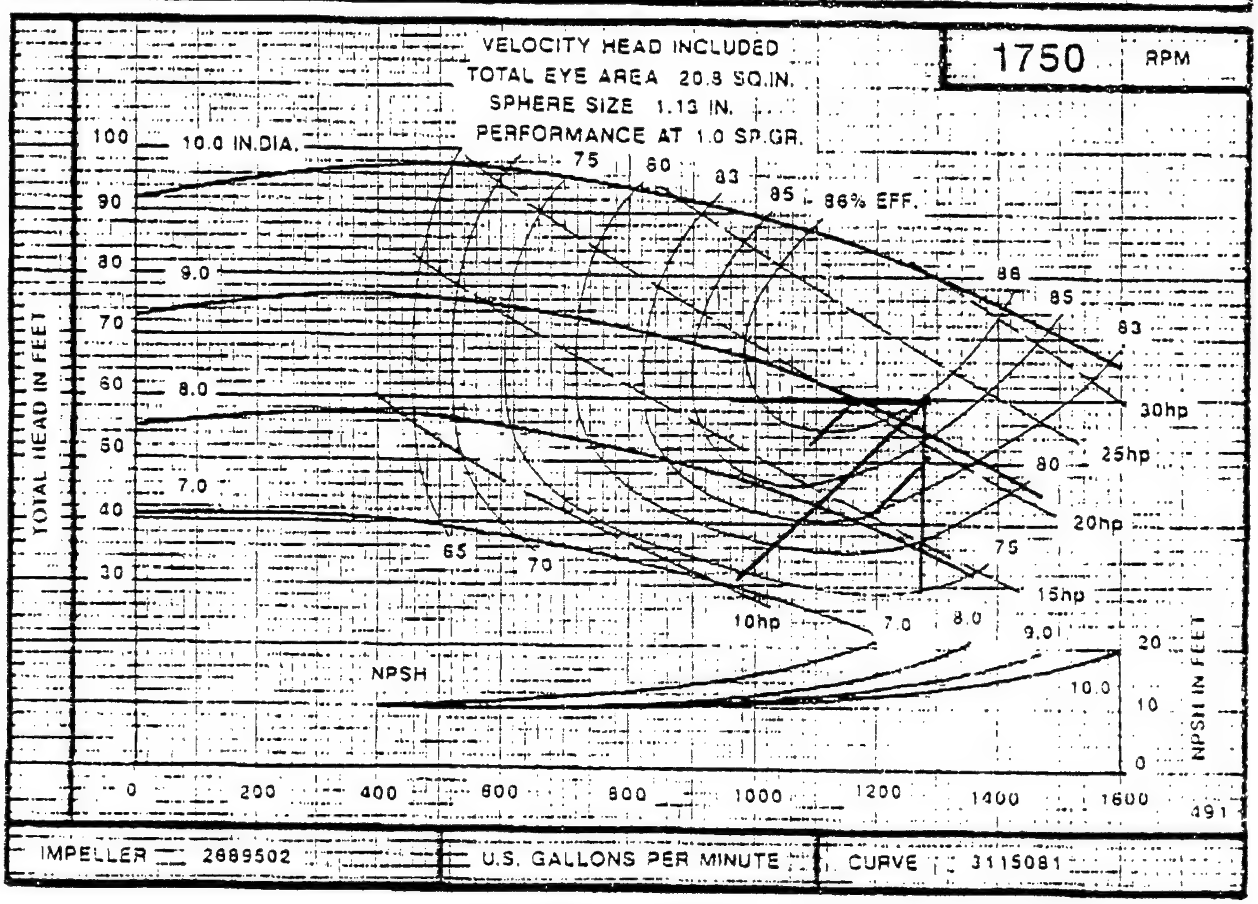
SECTION 2340
Page 16
July 5, 1991

END SUCTION GENERAL SERVICE PUMPS

Series C & F Type 1050A Size 5 x 6 x 10

Peerless Pump Company
a member of the Sterling Group





CHEM-SOLV, INC.
13037 WINDING TRAIL LANE
ST. LOUIS, MISSOURI 63131

OFFICE (314) 965-7148

FAX (314) 965-4740

FAX TRANSMITTAL

TO: Doug Anderson

COMPANY: USACERL

FAX NO: 217-373-3430

FROM: Mike Fridley

DATE: 6/19/95

NUMBER OF PAGES INCLUDING THIS PAGE: 4

Doug:

Here are some rough prices. The 5 PSI ΔP puts a lot of restrictions on selection.

I ran several with 10 PSI ΔP. There is a lot to discuss.

Thanks
Mike Fridley

43°F < 10 PSI
4P

Approx: 77,000

Alfa-Laval Thermal, Inc.

Plate Heat Exchanger Specification

Customer:	USACERL	Project:	Glycol Cooler
Inquiry No.	06/02/95 02:44:29 DA3	Date:	06/18/95
Item No:	43 F	End User:	Douglas Anderson
Cus. Ref.	Plate Heat Exchangers	Plant Location:	Champaign, IL

Alfa-Laval PHE Type		MX25-BFG
# of units in parallel		1
Heat transfer area (eff)	ft²	8089
Total number of plates		503

GUARANTEED PERFORMANCE

		Hot side	Cold side
Fluids		Water	Prop.glycol 25.0%
Mass flow rate	lb/h	640652	732369
Volume Flow rate	UsGpm	1280	1422
Inlet temperature	xF	53.0	42.0
Outlet temperature	xF	43.0	51.3
Pressure drop	psi	4.83	7.05
Heat exchanged	kBtu/h	6435.	
L.M.T.D	xF	1.33	

PHYSICAL PROPERTIES

Reference temperature	xF	48.0	46.6
Density	lb/ft3	62.4	64.1
Specific heat capacity	Btu/lb,xF	1.00	0.948
Thermal conductivity	Btu/ft,h,xF	0.338	0.276
Viscosity	cP	1.35	3.59

MECHANICAL DATA

Design/Test pressure	psig	150/225	150/225
Connection size in	in	10"	10"
Connection size out	in	10"	10"
Nozzle orientation	:	S1->S2	S4<-S3

MATERIALS

Plate material	:	AISI 316	
Gasket material	:	Nitrile	Nitrile
Connection material in	:	SS	SS
Connection material out	:	SS	SS

DIMENSIONS & WEIGHTS

For Dimensions - See Drawing

Liquid volume	ft3	64.2
Net weight, empty	lb	17000

The guaranteed thermal performance is conditioned on the

44°F @ 5 PSI ΔP

Approx: 27,500.00 ea.

Alfa-Laval Thermal, Inc.

Plate Heat Exchanger Specification

Customer:	USACERL	Project:	Glycol Cooler
Inquiry No.	06/02/95 02:44:29 DA2	Date:	06/18/95
Item No:	43 F	End User:	Douglas Anderson
Cus. Ref.	Plate Heat Exchangers	Plant Location:	Champaign, IL

Alfa-Laval PHE Type		M15-BFG
# of units in parallel		2
Heat transfer area (eff)	ft}	2449
Total number of plates		369

GUARANTEED PERFORMANCE

		Hot side	Cold side
Fluids		Water	Prop.glycol 25.0%
Mass flow rate	lb/h	320326	366184
Volume Flow rate	UsGpm	640	711
Inlet temperature	xF	53.0	42.0
Outlet temperature	xF	44.0	50.3
Pressure drop	psi	3.50	4.99
Heat exchanged	kBtu/h	2895.	
L.M.T.D	xF	2.31	

PHYSICAL PROPERTIES

Reference temperature	xF	48.5	46.2
Density	lb/ft3	62.4	64.2
Specific heat capacity	Btu/lb,xF	1.00	0.948
Thermal conductivity	Btu/ft,h,xF	0.339	0.276
Viscosity	cP	1.34	3.63

MECHANICAL DATA

Design/Test pressure	psig	150/225	150/225
Connection size in	in	6"	6"
Connection size out	in	6"	6"
Nozzle orientation	:	S1->S2	S4<-S3

MATERIALS

Plate material	:	AISI 316	
Gasket material	:	Nitrile	Nitrile
Connection material in	:	SS	SS
Connection material out	:	SS	SS

DIMENSIONS & WEIGHTS

For Dimensions - See Drawing

Liquid volume	ft3	20.1
Net weight, empty	lb	4600

The guaranteed thermal performance is conditioned on the accuracy of customer's data and customer's ability to

44 °F < 10 PSI
ΔP

Price Approx: $ 23,000.00 ea.

Alfa-Laval Thermal, Inc.

Plate Heat Exchanger Specification

Customer:	USACERL	Project:	Glycol Cooler
Inquiry No.	06/02/95 02:44:29 DA2	Date:	06/18/95
Item No:	44 F	End User:	Douglas Anderson
Cus. Ref.	Plate Heat Exchangers	Plant Location:	Champaign, IL

Alfa-Laval PHE Type		M15-BFG
# of units in parallel		2
Heat transfer area (eff)	ft}	1895
Total number of plates		286

GUARANTEED PERFORMANCE

		Hot side	Cold side
Fluids		Water	Prop.glycol 25.0%
Mass flow rate	lb/h	320326	366184
Volume Flow rate	UsGpm	640	711
Inlet temperature	xF	53.0	42.0
Outlet temperature	xF	44.0	50.3
Pressure drop	psi	5.85	8.56
Heat exchanged	kBtu/h	2895.	
L.M.T.D	xF	2.31	

PHYSICAL PROPERTIES

Reference temperature	xF	48.5	46.2
Density	lb/ft3	62.4	64.2
Specific heat capacity	Btu/lb,xF	1.00	0.948
Thermal conductivity	Btu/ft,h,xF	0.339	0.276
Viscosity	cP	1.34	3.63

MECHANICAL DATA

Design/Test pressure	psig	150/225	150/225
Connection size in	in	6"	6"
Connection size out	in	6"	6"
Nozzle orientation	:	S1->S2	S4<-S3

MATERIALS

Plate material	:	AISI 316	
Gasket material	:	Nitrile	Nitrile
Connection material in	:	SS	SS
Connection material out	:	SS	SS

DIMENSIONS & WEIGHTS

For Dimensions - See Drawing

Liquid volume	ft3	15.6
Net weight, empty	lb	4000

The guaranteed thermal performance is conditioned on the

Appendix F

CESAM-EN-CM
CEORL-ED-MS

January 1993
January 24, 1995

GENERAL SCOPE OF WORK

FOR A

LIMITED ENERGY STUDY

COOLING STORAGE SYSTEM

COMPUTER CENTER BUILDING 350/HDQTRS.BUILDING 390

ROCK ISLAND ARSENAL, ILLINOIS

Performed as part of the

ENERGY ENGINEERING ANALYSIS PROGRAM (EEAP) FY95

ROCK ISLAND ARSENAL, ILLINOIS
SCOPE OF WORK
FOR A
LIMITED ENERGY STUDY, EEAP FY95
COOLING STORAGE SYSTEM COMPUTER CENTER BUILDING 350/ HDQTRS. BUILDING 390

TABLE OF CONTENTS

1. <u>BRIEF DESCRIPTION OF WORK</u>: CERL(U.S. Army Construction Engineering Research Laboratories) shall:

1.1 Review previously completed Energy Engineering Analysis Program (EEAP) study which applies to the specific adjacent buildings, and/or systems, or energy conservation opportunity (ECO) covered by this study, if any had been done.

1.2 Perform a Limited Energy survey and Study of the specific Buildings 350/390, or their areas to collect all data required to evaluate the specific ECOs included in this study.

1.3 Reevaluate the specific project or ECO from the previous study, if any were done, to determine its economic feasibility based on revised criteria, current site conditions and technical applicability.

1.4 Evaluate specific ECOs to determine their energy savings potential and economic feasibility.

1.5 Provide project documentation for recommended ECOs as detailed herein.

1.6 Prepare a comprehensive report to document all work performed, the results and all recommendations.

2. <u>GENERAL</u>

2.1 This study is limited to the evaluation of the specific adjacent computer center building 350/390, systems that may be combined as one working unit, or ECOs listed in Annex A, DETAILED SCOPE OF WORK.

2.2 The information and analysis outlined herein are considered to be minimum requirements for adequate performance of this study.

2.3 For the study of buildings 350/390, and/or systems or ECOs listed in Annex A, all methods of energy conservation which are reasonable and practical shall be considered, including improvements of operational methods and procedures as well as the physical facilities. Cooling Storage Systems that have energy conservation opportunities which produce energy or dollar savings shall be documented in this report. Any energy conservation opportunity considered infeasible shall also be documented in the report with reasons for elimination.

2.4 The study shall consider the use of cooling storage systems that are energy sources applicable to these two adjacent buildings to be combined as one working unit, system, or ECO.

2.5 The "Energy Conservation Investment Program (ECIP) Guidance", described in letter from AFPI-ENO, dated 20 JAN 1994 and the latest revision from CEHSC-FU establishes criteria for ECIP projects and shall be used for performing the economic analyses of <u>all</u> ECOs and projects. The program, Life Cycle Cost In Design (LCCID), has been developed for performing life cycle cost calculations in accordance with ECIP guidelines and is referenced in the ECIP Guidance. If any program other than LCCID is proposed for life cycle cost analysis (LCCA), it must use the mode of calculation specified in the ECIP Guidance. The output must be in the format of the ECIP LCCA summary sheet, and it must be submitted for approval to the Contracting Officer.

2.6 Energy conservation opportunities (ECO) determined to be technically and economically feasible shall be developed into project/s acceptable to installation personnel. This may involve combining similar ECOs into larger packages which will qualify for ECIP, MCA, or PCIP funding, and determining in coordination with installation personnel the appropriate packaging and

implementation approach for all feasible ECOs.

2.6.1 Project/s which qualify for ECIP funding shall be identified, separately listed, and prioritized by the Savings to Investment Ratio (SIR).

2.6.2 All feasible non-ECIP projects shall be ranked in order of highest to lowest SIR.

2.6.3 At some installations Energy Conservation and Management (ECAM) funding will be used instead of ECIP funding. The criteria for each program is the same. The PWE will indicate which program is used at this installation. This Scope of Work mentions only ECIP, however, ECAM is also meant.

3. PROJECT MANAGEMENT

3.1 Project Managers. CERL shall designate a project manager to serve as a point of contact and liaison for work required under this contract. Upon award of this contract, the individual shall be immediately designated in writing. CERLs' designated project manager shall be approved by the Contracting Officer prior to commencement of work. This designated individual shall be responsible for coordination of work required under this contract. The Contracting Officer will designate a project manager to serve as the Government's point of contact and liaison for all work required under this contract.

3.2 Installation Assistance. The Commanding Officer or authorized representative at the installation will designate an individual to assist CERL in obtaining information and establishing contacts necessary to accomplish the work required under this contract. This individual will be the installation representative.

3.3 Public Disclosures. CERL shall make no public announcements or disclosures relative to information contained or developed in this contract, except as authorized by the Contracting Officer.

3.4 Meetings. Meetings will be scheduled whenever requested by CERL or the Contracting Officer for the resolution of questions or problems encountered in the performance of the work. CERLs' project manager and the Government's representative shall be required to attend and participate in all meetings pertinent to the work required under this contract as directed by the Contracting Officer. These meetings, if necessary, are in addition to the presentation and review conferences.

3.5 Site Visits, Inspections, and Investigations. CERL's shall visit and inspect/investigate the site of the project as necessary and required during the preparation and accomplishment of the work.

3.6 Records

3.6.1 CERL's shall provide a record of all significant conferences, meetings, discussions, verbal directions, telephone conversations, etc., with Government representative(s) relative to this contract in which CERL's and/or designated representative(s) thereof participated. These records shall be dated and shall identify the contract number, and modification number if applicable, participating personnel, subject discussed and conclusions reached. CERL shall forward to the Contracting Officer within ten calendar days, a reproducible copy of the records.

3.6.2 CERL shall provide a record of requests for and/or receipt of Government-furnished material, data, documents, information, etc., which if not furnished in a timely manner, would significantly impair the normal progression of the work under this contract. The records shall be dated and

shall identify the contract number and modification number, if applicable. CERL shall forward to the Contracting Officer within ten calendar days, a reproducible copy of the record of request or receipt of material.

3.7 Interviews. CERL and the Government's representative shall conduct entry and exit interviews with the PWE before starting work at the installation and after completion of the field work. The Government's representative shall schedule the interviews at least one week in advance.

3.7.1 Entry. The entry interview shall describe the intended procedures for the survey and shall be conducted prior to commencing work at the facility. As a minimum, the interview shall cover the following points:

a. Schedules.

b. Names of energy analysts who will be conducting the site survey.

c. Proposed working hours.

d. Support requirements from the Department of Public Works.

3.7.2 Exit. The exit interview shall briefly describe the items surveyed and probable areas of energy conservation. The interview shall also solicit input and advice from the PWE.

4. SERVICES AND MATERIALS. All services, materials (except those specifically enumerated to be furnished by the Government), plant, labor, supervision and travel necessary to perform the work and render the data required under this contract are included in the lump sum price of the contract.

5. PROJECT DOCUMENTATION. All ECOs which CERL has considered shall be included in one of the following categories and presented in the report as such:

5.1 ECIP Projects. To qualify as an ECIP project, an ECO, or several ECOs which have been combined, must have a construction cost estimate greater than $300,000, a Savings to Investment Ratio (SIR) greater than 1.25 and a simple payback period of less than ten years. For ECAM projects, the $300,000 limitation may not apply; in such cases, CERL shall check with the installation for guidance. The overall project and each discrete part of the project shall have an SIR greater than 1.25. All projects meeting the above criteria shall be arranged as specified in paragraph 2.7.1 and shall be provided with programming documentation. Programming documentation shall consist of a DD Form 1391, life cycle cost analysis (LCCA) summary sheet(s) (with necessary backup data to verify the numbers presented), and a Project Development Brochure (PDB). A LCCA summary sheet shall be developed for each ECO and for the overall project when more than one ECO are combined. The energy savings for projects consisting of multiple ECOs must take into account the synergistic effects of the individual ECOs. For projects and ECOs reevaluated from previous studies, the backup data shall consist of copies of the original calculations and analysis, with new pages revising the original calculations and analysis. In addition, the backup data shall include as much of the following as is available: the increment of work under which the project or ECO was developed in the previous study, title(s) of the project(s), the energy to cost (E/C) ratio, the benefit to cost (B/C) ratio, the current working estimate (CWE), and the payback period. The purpose of this information is to provide a means to prevent duplication of projects in any future reports.

5.2 Non-ECIP Projects. Projects which do not meet ECIP criteria with regard to cost estimate or payback period, but which have an SIR greater than

1.25 shall be documented. Projects or ECOs in this category shall be arranged as specified in paragraph 2.6.2 and shall be provided with the following documentation: the LCCA summary sheet completely filled out, a description of the work to be accomplished, backup data for the LCCA, ie, energy savings calculations and cost estimate(s), and the simple payback period. The energy savings for projects consisting of multiple ECOs must take into account the synergistic effects of the individual ECOs. In addition these projects shall have the necessary documentation prepared, as required by the Government's representative, for one of the following categories:

a. Quick Return on Investment Program (QRIP). This program is for projects which have a total cost greater than $3,000 but less than $100,000 and a simple payback period of two years or less.

b. Productivity Enhancing Capital Investment Program (PECIP). This program is for projects which have a total cost of greater than $3,000 but lees than $100,000 and a simple payback period of four years or less.

c. OSD Productivity Investment Funding (OSD PIF). This program is for projects which have a total cost of more than $100,000 and a simple payback period of four years or less.

The above programs and the required documentation forms are all described in detail in AR 5-4, Change No. 1.

d. Regular Military Construction Army (MCA) Program. This program is for projects which have a total cost greater than $300,000 and a simple payback period of four to twenty-five years. Documentation shall consist of DD Form 1391 and a PDB.

e. Low Cost/No Cost Projects. These are projects which the DPW can perform using his resources. Documentation shall be as required by the DPW.

5.3 Nonfeasible ECOs. All ECOs which CERL has considered but which are not feasible, shall be documented in the report with reasons and justifications showing why they were rejected.

6. DETAILED SCOPE OF WORK. The Detailed Scope of Work is contained in Annex A.

7. WORK TO BE ACCOMPLISHED.

7.1 Review Previous Studies. Review the previous EEAP study which applies to the specific building, system, or ECO covered by this study. This review should acquaint CERL with the work that has been performed previously. Much of the information CERL may need to develop the ECOs in this study may be contained in the previous study.

7.2 Perform Site Surveys. CERL shall obtain all necessary data to evaluate the ECOs or project/s by conducting a site survey. However, CERL is encouraged to use any data that may have been documented in any previous study. CERL shall document the site survey on forms developed for the survey, or standard forms, and submit these completed forms as part of the report. All test and/or measurement equipment shall be properly calibrated prior to its use.

7.3 Reevaluate Selected Projects. CERL shall reevaluate the projects and ECOs listed in Annex A. These are projects and ECOs that the previous study has identified but that have not been accomplished or only parts have been accomplished. If the project or ECO is acceptable as is, that is, there are no changes to the basic project or ECO, the energy savings shown in the previous project may be accepted as accurate but the energy cost and construction cost

estimates shall be updated based on the most current data available. With the above information the project shall then be analyzed based on current ECIP criteria. If the project or ECO is basically acceptable but some of the buildings in the original project have been deleted or new buildings can be added, the necessary changes shall be made to the energy savings, the energy costs and construction costs shall be updated, and the revised project or ECO shall then be analyzed using current ECIP guidance. If the original project or ECO has had numerous changes made to it so that all of the numbers are suspected of being inaccurate, but the project or ECO is still considered feasible, CERL shall develop the project from the beginning and analyze it with the current ECIP guidance. These projects shall be separately listed in the report.

7.4 Evaluate Selected ECOs. CERL shall analyze the ECOs listed in Annex A. These ECOs shall be analyzed in detail to determine their feasibility. SIRs shall be determined using current ECIP guidance. CERL shall provide all data and calculations needed to support the recommended ECO. All assumptions and engineering equations shall be clearly stated. Calculations shall be prepared showing how all numbers in the ECO were figured. Calculations shall be an orderly step-by-step progression from the first assumption to the final number. Descriptions of the products, manufacturers catalog cuts, pertinent drawings and sketches shall also be included. A LCCA summary sheet shall be prepared for each ECO and included as part of the supporting data.

7.5 Combine ECOs Into Recommended Projects. During the Interim Review Conference, as outlined in paragraph 7.6.1, CERL will be advised of the PWE's preferred packaging of recommended ECOs into projects for implementation. Some projects may be a combination of several ECOs, and others may contain only one. These projects will be evaluated and arranged as outlined in paragraphs 5.1, 5.2, and 5.3. Energy savings calculations shall take into account the synergistic effects of multiple ECOs within a project and the effects of one project upon another. The results of this effort will be reported in the Final Submittal per paragraph 7.6.2.

7.6 Submittals, Presentations and Reviews. The work accomplished shall be fully documented by a comprehensive report. The report shall have a table of contents and shall be indexed. Tabs and dividers shall clearly and distinctly divide sections, subsections, and appendices. All pages shall be numbered. Names of the persons primarily responsible for the project shall be included. CERL shall give a formal presentation of the interim submittal to installation, command, and other Government personnel. Slides or view graphs showing the results of the study to date shall be used during the presentation. During the presentation, the personnel in attendance shall be given ample opportunity to ask questions and discuss any changes deemed necessary to the study. A review conference will be conducted the same day, following the presentation. Each comment presented at the review conference will be discussed and resolved or action items assigned. It is anticipated that the presentation and review conference will require approximately one working day. The presentation and review conference will be at the installation on the date agreeable to the PWE, CERL and the Government's representative. The Contracting Officer may require a resubmittal of any document(s), if such document(s) are not approved because they are determined by the Contracting Officer to be inadequate for the intended purpose.

7.6.1 Interim Submittal. An interim (60%) report shall be submitted for review after the field survey has been completed and an analysis has been performed on all of the ECOs. The report shall indicate the work which has been accomplished to date, illustrate the methods and justifications of the approaches taken and contain a plan of the work remaining to complete the study. Calculations showing energy and dollar savings, SIR, and simple payback period of all the ECOs shall be included. The results of the ECO analyses shall be summarized by lists as follows:

a. All ECOs eliminated from consideration shall be grouped into one listing with reasons for their elimination as discussed in par 5.3.

b. All ECOs which were analyzed shall be grouped into two listings, recommended and non-recommended, each arranged in dessending order SIR. These lists may be subdivided by building or area as appropriate for the study.

CERL shall submit the Scope of Work and any modifications to the Scope of Work as an appendix to the report. A narrative summary describing the work and results to date shall be a part of this submittal. At the Interim Submittal and Review Conference, the Government's and CERL's representatives shall coordinate with the PWE to provide CERL with direction for packaging or combining ECOs for programming purposes and also indicate the fiscal year for which the programming or implementation documentation shall be prepared. The survey forms completed during this audit shall be submitted with this report. The survey forms only may be submitted in final form with this submittal. They should be clearly marked at the time of submission that they are to be retained. They shall be bound in a standard three-ring binder which will allow repeated disassembly and reassembly of the material contained within.

7.6.2 Final Submittal. CERL shall prepare and submit the final report when all sections of the report are 100% complete and all comments from the interim submittal have been resolved. CERL shall submit the Scope of Work for the study and any modifications to the Scope of Work as an appendix to the submittal. The report shall contain a narrative summary of conclusions and recommendations, together with all raw and supporting data, methods used, and sources of information. The report shall integrate all aspects of the study. The recommended projects, as determined in accordance with paragraph 5, shall be presented in order of priority by SIR. The lists of ECOs specified in paragraph 7.6.1 shall also be included for continuity. The final report and all appendices shall be bound in standard three-ring binders which will allow repeated disassembly and reassembly. The final report shall be arranged to include:

a. An Executive Summary to give a brief overview of what was accomplished and the results of this study using graphs, tables and charts as much as possible (see Annex B for minimum requirements).

b. The narrative report describing the problem to be studied, the approach to be used, and the results of this study.

c. Documentation for the recommended projects (includes LCCA Summary Sheets).

d. Appendices to include as a minimum:

1) Energy cost development and backup data

2) Detailed calculations

3) Cost estimates

4) Computer printouts (where applicable)

5) Scope of Work

LOUISVILLE DISTRICT CORPS OF ENGINEERS
ENGINEERING DIVISION, A/E MANAGEMENT BRANCH (CEORL-ED-MS)

ANNEX A
DETAILED SCOPE OF WORK
ROCK ISLAND ARSENAL, IL

January 24, 1995

1. PROJECT NAME & LOCATION: - FY95 Rock Island Arsenal Limited Energy Study (LES), Cooling Storage System ECOs (Energy Conservation Opportunities) are as follows:

A. Cooling Storage System survey for Administration/Computer Center, Building 350 that is a 6-story structure having 446,477 square feet.

Building 350, blt. 1918, a converted warehouse facility is now an ADP computer center, administrative, communications, and a post restaurant. It is located on Rodman Avenue between W. Pershing Circle and Buffington Drive, and is adjacent to Headquarters Administration. See Figure A-1.1, Location Map.

Presently, a 750 ton steam absorption chiller and associated equipment in Building 348 provides chilled water serving all cooling needs of Building 390 and part of Building 350. Chilled water for Building 350 is supplied through a chilled water loop by four (4) 200 ton electric driven air cooled chillers that are dedicated to the computer systems (of which total capacity is not used), one (1) 150 ton absorption chiller, one (1) 174 ton absorption chiller, and one (1) 125 ton electric driven air cooled chiller, and a separate loop is dedicated to the computers. Heat is supplied to both buildings by steam piped from a central heating plant. The interior areas of Building 350 are served by thermostatically controlled air handling units, some which operate on a timer only during scheduled occupied periods. The perimeter rooms in Building 350 are heated with hot water convectors.

B. Cooling Storage System survey for Post Headquarters, Building 390 that is a large "H" shaped four story structure having 150,845 square feet.

Building 390, blt. 1942, is the headquarters administration building, and located on Rodman Avenue between W. Pershing Circle and Buffington Drive. See Figure A-1.1, Location Map.

Presently, Building 390 is entirely air conditioned using several multizone air handling units. As stated in paragraph A above, chilled water for the building is provided from a 750 ton absorption chiller located in Building 348. The building is heated using steam from a central heating plant. All of the air handling units operate on a timer only during scheduled occupied periods.

C. The study shall be completed in two parts. The study shall compare overall energy savings should the present system be replaced by one of the alternatives presented.

1. The study shall compare the following systems for Building 350 alone.

a. Ice Thermal Storage System.

b. Gas Fired Absorption Chiller System.

c. Water Cooled Centrifugal Chiller System.

2. The study then shall compare those same alternatives for a system that would serve both Buildings 350 and 390.

2. GENERAL SOW vs. DETAILED SOW: The General Scope of Work (GSOW) will

apply to contract efforts as modified by the Detailed SOW. Should conflicts occur between the GSOW and the Detailed SOW, the Detailed SOW shall govern.

3. RESPECTIVE POC's for this study:
Louisville District COE- Charles (Chuck) Lockman/CEORL-ED-MS
Contracting Officer Representative and POC
(502) 582-6040, fax #6763, or 5281

Rock Island Arsenal PWE- David Osborn/SMCRI-PWE, or Jim Thompson
↑(309) 782-2393, fax#2550, ↑(309) 782-2681

CERL- Chang Sohn P/M, or David Johnsich x7275
CERL (Construction Engineering Research Lab.)
P. O. Box 9005
Champaign, IL 61826-9005
(217) 373-6790, or FAX# (217) 373-6740

4. SCOPE:
4.1 CERL shall provide all work necessary to complete the Limited Energy Study as defined by the GSOW including the Annexes. Information and instructions contained within the DSOW are provided as a means for CERL Project Manager to expand or modify the GSOW as may be needed to suit the study for project area listed in 1. above. This LES is much more flexible than the standard EEAP study, and is meant to address specific opportunities, buildings or systems that the installation feels have high potential for energy or dollar savings.

4.2 The study will analyze a Cooling Storage System/s in Buildings 350 and 390 for useages by the Using Agency, material, utilities, and other components of the operations, and determine any energy savings methods/ recommendations for this study. This could include interview of personnel to gather data for quantities, and operations. Alternate energy sources could be included.

4.3 The study will consider new designs for energy trends that make these computer centers more cost effective and energy saving.

4.4 If metering of a facility is required, CERL shall assist the PWE in arranging for the installation of electrical metering, however, existing data is available at the installation, and by other studies/ surveys.

5. DETAILED REQUIREMENTS: All detail requirements selected at Rock Island Arsenal for the purpose of this study, shall specifically include the specific buildings 350 and 390 as listed in paragraph 1. above and projects identified by the PWE staff.

The contractor will review existing building drawings, survey and monitor existing lights, and analyze the listed ECOs, and analyze additional ECOs readily discovered during the field survey.

6. PERFORMANCE: The total time required for completion of the study and the performance of all work shall not be more than 180 calendar days from the Notice to Proceed (NTP) on the contract. If the study takes CERL less time than scheduled to achieve, a shortened schedule for submittal and coordination of review and interim review meeting at the installation may be coordinated CERL with all parties involved in the review process. Figure A-6.1 is a schedule of pertinent events and milestone dates for acceptable performance of the study at Rock Island Arsenal. Changes or adjustments made to the SOW during the term of the project study shall be make by the COE.

7. SUBMITTALS: CERLs Project Manager shall provide direct distribution of all required submittals and documents in the numbers as listed in Figure A-7.1.

8. GOVERNMENT-FURNISHED INFORMATION: The following list of reference documents will be furnished to CERL:

a. ETSs 1110-3-254, Use of Electric Power for Comfort Space Heating (if applicable), and 1110-3-282 Energy Conservation

b. Energy Conservation Investment Program (ECIP) Guidance, dated 20 Jan 1994 and the latest revision with current energy prices and discount factors for life cycle cost analysis.

c. TM 5-785, Engineering Weather Data.

B-3

d. AR 5-4, Change No. 1, Department of the Army Productivity Improvement Program.

e. AR 415-15, 1 Jan 84, Military Construction, Army (MCA) Program Development

f. The latest MCP Index.

g. Drawings at the PWE of each facility.

h. Reports listed in ECO information listed above which will assist in the development of the study for each facility.

9. LCCID FROM BLAST: Life Cycle Costing in Design (LCCID) will be used performing the economic calculations for ECIP and non-ECIP ECOs.

10. If it is possible that the buildings in this study will be subject to the computer modeling requirements of paragraph 2.6 of the GSOW, then the simulation programs acceptable to the office doing the technical review should be listed in the detailed scope of work. Some acceptable simulation programs follow:

a. Building Loads and System Thermodynamics (BLAST) *

b. DOE 2.1B *

c. Carrier E20 or Hourly Analysis Program (HAP) **

d. Trane Air-Conditioning Economics (TRACE) **

* Very accurate, but requires a lot of time for input; therefore it is rather expensive for straightforward projects.

** Adequate for load determination, equipment selection, and energy performance for most projects.

11. LIST OF EEAP STUDIES/REPORTS, ROCK ISLAND ARSENAL: A review of the following is considered to be of assistance for in the GSOW. The COE and PWE Offices have a copy for review, and/or loan:

a. EEAP, Hydroelectric Power Plant, 05/01/83
b. EMCS, for 31 Buildings, 07/01/84
c. Electrical Dist. Study Bldg.#350, 07/01/87, Black & Veatch
d. Energy Monitoring and Control System, 07/01/87
e. EEAP, LES Lights Bldg. 350, Interim Report, 10/11/93, Systems Corp.
    Final Report, 11/05/93
    Executive Summary, 11/05/93

FIGURE A-6.1.

SCHEDULE FOR FY95 EEAP, LIMITED ENERGY STUDY,
COOLING STORAGE SYSTEM, COMPUTER CENTER ADJ. BLDGS. 350/390
ROCK ISLAND ARSENAL, IL

MILESTONE	DATE
Letter received FOA-CEMP-ET for scheduling......	January 17, 1995
FOA Coordination call to PWE (POC)..............	December 19, 1994
Submittal of Schedule to CEMP-ET-FOA............	February 10, 1995
FOA tel. contact w/RIA POC PreDSOW..............	January 13, 1995
DSOW-FOA submit to CERL,PWE,& MACOM	January 24, 1995
SOW Meeting/Site Visit CERL w/FOA, PWE, & MACOM.	February 07, 1995
CERLs Entry Interview/Site Visit................	February 07, 1995
Finalized SOW by FOA to CERL, PWE & MACOM.......	February 10, 1995
Proposal Letter received from CERL to FOA.......	February 10, 1995
MIPIR Award of Funds to CERL....................	February 24, 1995
CERL Submits 60% LES to FOA, PWE, & MACOM.......	April 24, 1995
Formal CERL 60% LES & Review Meeting @ RIA...... w/PWE, MACOM, FOA (60 days from award)	May 02, 1995
Exit Interview CERL w/PWE.......................	May 02, 1995
Final Submittal (120 days from award)........... w/1391 information	June 30, 1995

January 24, 1995

FIGURE A-7.1. Distribution of Submittals: The A/E shall make direct submittal and responses to comments as indicated by the following schedule:

Organization	Correspondence	Executive Summary	Reports	Fieldnotes
COMMANDER,US Army Engineer District,Louisville ATTN: CEORL-ED-MS/Charles Lockman (Rm.607) P.O. Box 59 (express-600 Dr.Martin King Place) Louisville, KY 40201-0059 (tel. 502-582-6041, or fax# 6763, or 5281)	1	1	1	1*
COMMANDER, Rock Island Arsenal ATTN: SMCRI-PWE/David Osborn, SW wing Rodman Avenue, Building 102, 1st Floor Rock Island, IL 61299-5000 (tel. 309-782-2393, or fax# 2550)	1	1	1	1*
HQ AMCCOM, Rock Island Arsenal (MACOM) ATTN: AMCCOM/Bob Burchett, Energy Officer Rodman Avenue, Building 108, 1st Floor Rock Island, IL 61299-5000 (tel. 309-782-1410)	1	1	1	1*
COMMANDER, US Army Material Command ATTN: AMCEN-F/MS. Custer 5001 Eisenhower Avenue, Rm. 2158 Alexandria, VA 22333-0001 (tel. 703-274-9296, or fax#3633)	1	1	1	1*
COMMANDER, US Army Engineer District,Mobile ATTN: CESAM-EN-CC/Tony Battaglia (EEAP TCX) P.O. Box 2288 Mobile, AL 36628-0001 (tel. 205-690-2618, or fax# 2424)	1	1	1	1*
COMMANDER, US Army Engineer Div.,Ohio River ATTN: CEORD-DL-M/Joe Semrad P.O. Box 1159 Cincinnati, OH 45201-1159 (tel. 513-684-3975)	0	1**	0	0
COMMANDER, US Army Corps of Engineers ATTN: CEMP-ET/Dan Gentil (EEAP Mgr.) 20 Massachusetts Avenue Washington, D.C. 20314-1000 (tel. 202-272-0430)	0	1**	0	0
COMMANDER, US Army Logistics Evaluation Agency ATTN: LOEA-PL/Mr. Keath New Cumberland Army Depot New Cumberland, Pa. 17070-5006	0	1**	0	0

* Field Notes submitted in final at Interim submittal.
** Submit copies of the final Executive Summary Only

ANNEX B

EXECUTIVE SUMMARY GUIDELINE

1. Introduction.

2. Building Data (types, number of similar buildings, sizes, etc.)

3. Present Energy Consumption of Buildings or Systems Studied.

   o Total Annual Energy Used.

   o Source Energy Consumption.
     Electricity - KWH, Dollars, BTU
     Fuel Oil - GALS, Dollars, BTU
     Natural Gas - THERMS, Dollars, BTU
     Propane - GALS, Dollars, BTU
     Other - QTY, Dollars, BTU

4. Reevaluated Projects Results.

5. Energy Conservation Analysis.

   o ECOs Investigated.

   o ECOs Recommended.

   o ECOs Rejected. (Provide economics or reasons)

   o ECIP Projects Developed. (Provide list)*

   o Non-ECIP Projects Developed. (Provide list)*

   o Operational or Policy Change Recommendations.

* Include the following data from the life cycle cost analysis summary sheet: the cost (construction plus SIOH), the annual energy savings (type and amount), the annual dollar savings, the SIR, the simple payback period and the analysis date.

6. Energy and Cost Savings.

   o Total Potential Energy and Cost Savings.

   o Percentage of Energy Conserved.

   o Energy Use and Cost Before and After the Energy Conservation Opportunities are Implemented.

ANNEX C

REQUIRED DD FORM 1391 DATA

To facilitate ECIP project approval, the following supplemental data shall be provided:

a. In title block clearly identify projects as "ECIP."

b. Complete description of each item of work to be accomplished including quantity, square footage, etc.

c. A comprehensive list of buildings, zones, or areas including building numbers, square foot floor area, designated temporary or permanent, and usage (administration, patient treatment, etc.).

d. List references, and assumptions, and provide calculations to support dollar and energy savings, and indicate any added costs.

(1) If a specific building, zone, or area is used for sample calculations, identify building, zone or area, category, orientation, square footage, floor area, window and wall area for each exposure.

(2) Identify weather data source.

(3) Identify infiltration assumptions before and after improvements.

(4) Include source of expertise and demonstrate savings claimed. Identify any special or critical environmental conditions such as pressure relationships, exhaust or outside air quantities, temperatures, humidity, etc.

e. Claims for boiler efficiency improvements must identify data to support present properly adjusted boiler operation and future expected efficiency. If full replacement of boilers is indicated, explain rejection of alternatives such as replace burners, nonfunctioning controls, etc. Assessment of the complete existing installation is required to make accurate determinations of required retrofit actions.

f. Lighting retrofit projects must identify number and type of fixtures, and wattage of each fixture being deleted and installed. New lighting shall be only of the level to meet current criteria. Lamp changes in existing fixtures is not considered an ECIP type project.

g. An ECIP life cycle cost analysis summary sheet as shown in the ECIP Guidance shall be provided for the complete project and for each discrete part included in the project. The SIR is applicable to all segments of the project. Supporting documentation consisting of basic engineering and economic calculations showing how savings were determined shall be included.

h. The DD Form 1391 face sheet shall include, for the complete project, the annual dollar and MBTU savings, SIR, simple amortization period and a statement attesting that all buildings and retrofit actions will be in active use throughout the amortization period.

i. The calendar year in which the cost was calculated shall be clearly shown on the DD Form 1391.

j. For each temporary building included in a project, separate documentation is required showing (1) a minimum 10-year continuing need, based on the installation's annual real property utilization survey, for active building retention after

retrofit, (2) the specific retrofit action applicable and (3) an economic analysis supporting the specific retrofit.

k. Nonappropriated funded facilities will not be included in an ECIP project without an accompanying statement certifying that utility costs are not reimbursable.

l. Any requirements required by ECIP guidance dated 4 Nov 1992 and any revisions thereto. Note that unescalated costs/savings are to be used in the economic analyses.

m. The five digit category number for all ECIP projects except for Family Housing is 80000. The category code number for Family Housing projects is 71100.

GLOSSARY OF ACRONYMS

A/E	Architect Engineer
AR	Army Regulation
B/C	Benefit to Cost
COE	Corps of Engineers
CWE	Current Working Estimate
DPW	Department of Public Works
DOD	Department of Defense
DSOW	Detailed Scope of Work
E/C	Energy to Cost
ECAM	Energy Conservation and Management
ECIP	Energy Conservation Investment Program
ECO	Energy Conservation Opportunity
EEAP	Energy Engineering Analysis Program
EHSC	Engineering and Housing Support
EMCS	Energy Monitoring Analysis Program
ESOS	Energy Savings Opportunity Survey
GSOW	General Scope of Work
HQUSACE	Headquarters US Army Corps of Engineers
LCCA	Life Cycle Cost Analysis
LCCID	Life Cycle Cost In Design
MACOM	Major Army Command
MCA	Military Construction Army
NECPA	National Energy Conservation Policy Act
OSD PIF	OSD Productivity Capital Investment Funding
PCIP	Productivity Capital Investment Program
PDB	Project Document Brochure
PECIP	Productivity Enhancing Capital Investment Program
POC	Point of Contact
QRIP	Quick Return on Investment Program
SIR	Savings Investment Ratios
TCX	Technical Center of Expertise
CERL	U.S. Army Construction Engineering Research Laboratories

Appendix G

LIFE CYCLE COST ANALYSIS SUMMARY STUDY: ROCK
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) LCCID FY95 (92)
INSTALLATION & LOCATION: ROCK ISLAND ARREGION NOS. 5 CENSUS: 2
PROJECT NO. & TITLE: 00 STORAGE COOLING SYSTEM
FISCAL YEAR 1998 DISCRETE PORTION NAME: CWS
ANALYSIS DATE: 07-24-96 ECONOMIC LIFE 25 YEARS PREPARED BY: DOUG ANDERSON

1. INVESTMENT

A. CONSTRUCTION COST	$ 438618.		
B. SIOH	$ 29721.		
C. DESIGN COST	$ 32423.		
D. TOTAL COST (1A+1B+1C)	$ 500762.		
E. SALVAGE VALUE OF EXISTING EQUIPMENT		$ 0.	
F. PUBLIC UTILITY COMPANY REBATE		$ 0.	
G. TOTAL INVESTMENT (1D - 1E - 1F)			$ 500762.

2. ENERGY SAVINGS (+) / COST (-)
DATE OF NISTIR 85-3273-X USED FOR DISCOUNT FACTORS OCT 1994

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ 10.17	2315.	$ 23544.	18.89	$ 444738.
B. DIST	$ .00	0.	$ 0.	23.38	$ 0.
C. RESID	$ .00	0.	$ 0.	26.65	$ 0.
D. NAT G	$ .00	0.	$ 0.	22.38	$ 0.
E. COAL	$ .00	0.	$ 0.	20.01	$ 0.
F. PPG	$ .00	0.	$ 0.	22.06	$ 0.
M. DEMAND SAVINGS			$ 56536.	17.41	$ 984292.
N. TOTAL		2315.	$ 80080.		$ 1429029.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ 0.
(1) DISCOUNT FACTOR (TABLE A) 17.41
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ 0.

B. NON RECURRING SAVINGS(+) / COSTS(-)

ITEM	SAVINGS(+) COST(-) (1)	YR OC (2)	DISCNT FACTR (3)	DISCOUNTED SAVINGS(+)/ COST(-)(4)
d. TOTAL	$ 0.			0.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+)/COST(-)(3A2+3Bd4) $ 0.

4. FIRST YEAR DOLLAR SAVINGS 2N3+3A+(3Bd1/(YRS ECONOMIC LIFE)) $ 80080.

5. SIMPLE PAYBACK PERIOD (1G/4) 6.25 YEARS

6. TOTAL NET DISCOUNTED SAVINGS (2N5+3C) $ 1429029.

7. SAVINGS TO INVESTMENT RATIO (SIR)=(6 / 1G)= 2.85
(IF < 1 PROJECT DOES NOT QUALIFY)

8. ADJUSTED INTERNAL RATE OF RETURN (AIRR): 7.41 %

Appendix H

Numerous comments were provided by reviewers of this report and were greatly appreciated. As many of the comments as possible were addressed within the body of the report. A few of the comments and responses are provided:

Q: It is stated that all four (200-ton) electric chillers were observed to be running simultaneously. This was for a space that has a peak load of 534 tons according to a BLAST model. Apparently at the time the investigators were not able to cetermine at what percent of capacity the chillers were operating. This is understandable. However, it is very important that this be investigated before this report is finalized. Getting this information, especially at this time of year, would be an excellent check on the model; and it could have a strong bearing on the results of the study.

R: As indicated in the report, hourly operational data on the four units were collected between August 7 and August 13 of 1995, which was a very hot week in Rock Island. The peak total cooling load during this period was measured to be 517 tons, indicating that the BLAST model is within acceptable bounds and verifying the results of the study.

Q: Little background was presented to verify the validity of the various costs associated with the report. It may be that not all costs were included in the analysis, such as design costs or construction costs; but shis should not seriously affect the conclusions arrived at in the report.

R: Appendix E has been added to provide documentation of the quotes for pumps and the plate heat exchanger.

Q: A location map showing where these two buildings are at on RIA in the report would help others at a later time in referencing the buildings. If you have photos could they have been utilized to show the existing units along with their data identification information, or building facade? Sometimes those persons who can't physically go to the site for mechanical inspections could readily obtain information from photos.

R: Appendix B has been added that includes both a site map and photographs.